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The Soils of Tennessee

University of Tennessee Agricultural Experiment Station

Edward T. Sanford

UNIVERSITY OF TENNESSEE

Agricultural Experiment Station

BULLETIN

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THE SOILS OF TENNESSEE.

by Charles F. Vanderford

Bulletins of this Station will be sent, upon application, free of charge, to any Farmer in the State.

KNOXVILLE, TENNESSEE, U. S. A.

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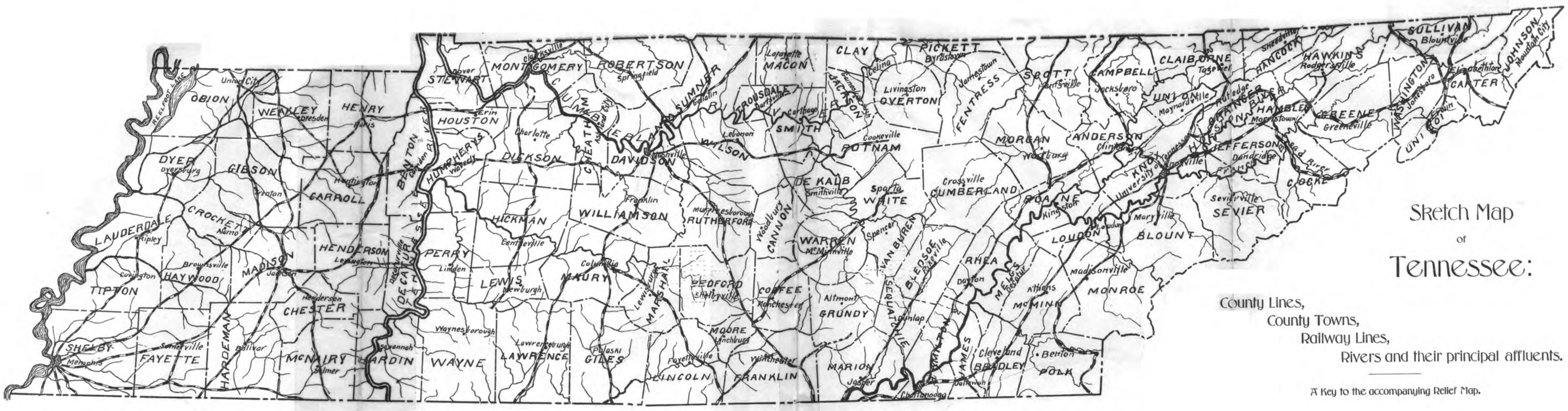
Photogravure
of
Relief Map
of
Tennessee:
Compiled from most recent Topographical Surveys,
by the
Agricultural Experiment Station
of the
UNIVERSITY OF TENNESSEE,
Knoxville, Tenn.
1897.



Sketch Map
of
Tennessee:
County Lines,
County Towns,
Railway Lines,
Rivers and their principal affluents.

A Key to the accompanying Relief Map.

PREFACE.

It is a part of the plan of the Tennessee Agricultural Experiment Station to investigate the agricultural resources of the State of Tennessee. It is well enough to make variety tests of vegetables, fruits, and all agricultural plants; to analyze fertilizers and feeding stuffs; to compare breeds of stock, and methods of feeding them; but while we do such of these things as seem most important to be done for the instruction or protection of the farmers of Tennessee, this Station will endeavor to do some work of a permanent character. Plans were early made, therefore, for studying the climate, the soils, the flora and fauna of Tennessee, with especial reference to the development of agriculture, horticulture, and the animal industries. This undertaking is as vast as it is comprehensive. When we consider that Tennessee covers 42,000 square miles, averaging 400 miles long from the Smokies to the Mississippi; that its surface is spread out over mountains, plateaus, valleys, and plains, ranging in elevation from 6,400 feet down to 300 feet; that we have thus in one State all the life zones from the Boreal to the lower Austral, and nearly all the soil formations known to North America, it is apparent that it will require the labor of a great number of scientific workers for a long time to make even a reconnoisance of the resources of so varied a territory. Although plans have been made in the Station Council for carrying out this work, it would be unwise to publish them, since they must inevitably be changed from time to time. All we can promise is, that this Station will report the results of its investigations as fast as it can be sure of them.

A number of Bulletins already published give results of some portions of this work. Among the more important ones may be mentioned: Vol. V, No. 2, Grasses of Tennessee, Part 1, and Vol. VII, No. 1, Grasses of Tennessee, Part 2 (these two parts give the result of a thorough investigation of the grasses of the State from a botanical standpoint); Vol. IX, No. 1, and Vol. X, No. 1, Apples of Tennessee Origin; Vol. IX, No. 3, A Contribution to the Study of Southern Feeding Stuffs, etc.

The Station commenced some six years ago a systematic survey of the soils of the State. A preliminary soil map was compiled, and typical samples of many of the virgin soils were collected and carefully studied. Notes were made at each place upon the geology, the flora and fauna, and the agricultural treatment and products of the soil.

The greatest difficulty encountered in studying the soils from an agricultural standpoint was the very limited number of intelligent observers. It has thus been found absolutely necessary to first instruct farmers how to observe in order to get intelligent reports upon the methods of treating the soils, and upon the crops grown upon them. As a method of educating such observers and of giving the farmers of the State the benefit of the more practical observations made upon some of the typical soils, this preliminary report on the soils of Tennessee has been prepared by the Agriculturist. It is not intended as a complete treatise on the subject. The Station has a considerable amount of material which must be reserved for future discussion. This Bulletin contains, after a description of the objects and methods of the survey, the physical and chemical analyses and climatological and botanical relations of a number of the most important typical soils of Tennessee. The notes made by the Agriculturist on the agricultural treatment of the soil have been pretty fully incorporated for the purpose of interesting the practical farmer.

This Bulletin is accompanied by the preliminary soil map of the State, which was compiled by the Station, with the assistance of the United States Geological Survey, and the Division of Soils of the United States Department of Agriculture. For the purposes of instruction and further study, this soil map has been put upon a relief map of Tennessee 10 feet 4 inches long by 2 feet 10 inches wide, which was prepared by the Station in co-operation with the U. S. Geological Survey. A half-tone plate made from a photograph of this relief map model is inserted in the Bulletin. Although the paper here published represents in itself a great amount of work, no special claims are made for it. It is only hoped that it will form the basis of a thorough study of the soils of Tennessee. If this is done, we must have the co-operation of the farmers of the State, for whose instruction it is published.

In submitting the Bulletin, we desire to make due acknowledgment to Prof. MILTON WHITNEY, of the Division of Soils, in the United States Department of Agriculture, for advice and assistance in the preparation of the soil map, and in making the mechanical analyses; to Mr. BAILEY WILLIS, of the United States Geological Survey, for his advice in regard to the soil map; and to Dr. J. M. SAFFORD, State Geologist, for suggestions.

CHAS. W. DABNEY,
President.

INDEX.

THE SOILS OF TENNESSEE.

CHAS. F. VANDERFORD.

Arguments for and against the value of chemical soil analyses have been urged by scientific investigators in this country as well as in European States. By some it has been stoutly maintained that the productiveness of the soil can be measured by the amount of certain essential elements of plant food contained in the upper arable stratum and the few inches of subsoil just below. By others it is claimed that the results of soil analyses, and the attempts to interpret them, have differed so frequently and so positively from the indications of practical work in the field, that such tests are of too little worth to justify the labor and cost of making them. In this contention, as in many others, the truth lies between the extremes.

We can trust the judgment of an old farmer as to the leading characteristics and average fertility of land. "Quick wittedness and openness of vision, intellectual audacity, yet strong common sense," are distinguishing traits of the American farmer, enabling him to make "rapid rough-and-ready reconnaissance of new soils under varying climatic conditions," and to make choice of the best. The trees and undergrowth of the forest, the luxuriant grasses of the unbroken prairie, the waters of the springs, and the varying but always suggestive colors and consistency of the newly broken soil, are tokens plainly and easily understood. Close observation and common sense make it easy for the pioneer to select a piece of land to be cleared, and to choose breadths of territory rich with promise for the future.

Our once almost unlimited territory open to the choice of the home-seeker is no longer available. We have become a great nation, and the right of private property has almost entirely absorbed the public domain. In Tennessee there are no public lands. Our forests are rapidly disappearing. After a little more than one hundred years of existence as a separate State, our people are brought face to face with the same conditions as confront the citizens of states many centuries old. We are already forced to consider how we may save our lands from ruin and keep our homes an abiding place for a contented and happy posterity.

The sound common sense which justified the pioneer farmer in his judgment of the value of a soil may still be trusted when his opinion is asked about the fields he planted and cultivated, watched and cared for; and his estimate of the value of the lands around about can also be trusted. If those who come after him shall inherit his wisdom and clear-sighted knowledge of what the soil was and is, and shall have learned how to keep it, loving the land because it was their father's home, and cherish it as the home of the sons and daughters that may come into their own households, all will be well.

One who travels over the State, by rail or by country road, will see everywhere, in the richest as well as in the poorest sections, broad stretches of land so much worn as to be unproductive, and very many of such areas properly classed as abandoned land. "Old fields," turned out to be gradually but surely reduced to utter barrenness, are unpleasantly numerous, not only in the mountainous region of East Tennessee, and along or near the escarpments of the highland rim of Middle Tennessee, but in the more level land of the great central basin of the State, and in those counties of West Tennessee most famed for rich and productive soil. The proportion of such land so much worn and so badly wasted as to make it impossible to restore it for any useful purpose, is much less than is suggested by superficial observation. In almost every instance these "old fields," when cleared from the forest, were chosen by the farmers of that day as the best lands in their possession. Their judgment was doubtless well founded. There are tens of thousands of acres which are beyond redemption save by reforestation, but of the immense area now regarded as abandoned land, not one-twentieth is beyond hope of recovery by timely efforts. The area of land once under the plow, now regarded as unfit for cultivation and not considered of value enough to be protected by fence, has been increasing year by year. A conservative estimate of the territory abandoned cannot be stated at less than a half million of acres, to which must be added an equal, and probably a larger area of land inside farm boundary fences, but given over to weeds, briars and useless brush growth.

The problem is to maintain the productiveness of the best lands under cultivation, and such as are used for orchard, garden, meadow, pasture and woodland; to restore such areas as are now considered unprofitable, and to determine, if we can, the best, surest, and quickest ways to these ends. Plainly one of the things to be done is to find out all the facts as to the composition, physical and chemical, of soils such as were in the first instance chosen by old and skilful common-sense farmers. This can be done best by an investigation of the virgin soils.

To restore depleted fertility, it is also plainly necessary to accomplish in every way a return to the original physical conditions, and by every means known to the chemist and the biologist to add the elements of plant food in manner and in kind readily available to growing plants. To attempt one part of the work of restoration and forego the other is to invite failure.

If our investigations of a soil are limited to the study of its mechanical condition, the fineness or coarseness of its particles, capacity for holding water, capillarity, porosity, &c., and the methods of cultivation best calculated to secure the presence of a store of water for the plants, we shall stop short of what we ought to know. We can conceive of a mixture of fine sand and clay closely representing the best or the worst physical characteristics of soils in which to grow plants; however abundant the water held by such a mixture there could be no fruitful growth. To such a mixture, or to a mass of pure sand, we can add the indispensable constituents of plant food soluble in water, and so imitate a soil in which plants may attain growth and productiveness. It is possible in a very limited way to surround a plant growing in such an artificial soil by the proper conditions of light and warmth, and so determine with an approach to accuracy the essentials for best development.

For this work, in the greenhouse laboratory, there must be a study of chemical and biological conditions as modifying and controlling the more easily decided physical conditions of the soil.

When we have compounded an artificial soil with utmost care, so much sand, so much clay, so much of the several constituents known to be essential and in water solution easily available, and have in all ways as nearly as possible surrounded the captive plant with just such conditions as are best for its kind, we can determine a few things with a moderate degree of certainty; but we shall in most cases leave a great many things not decided, and some things not at all understood. We can approach the mystery of plant life, just as we can the no more profound mystery of animal life, but must stop short of completely knowing. The thimbleful of earth in which we plant a mustard seed holds unsolved problems.

While thus brought to acknowledge that we are always and everywhere meeting the "thus far" beyond which we can not go, there is always and everywhere encouragement to seek further knowledge. The more clearly we recognize the steadfastness of His laws, the absolute certainty of their operation, the more earnest should be our striving to know, so that we may gather the rewards of obedience. In the sober work of digging into the earth, in the hopeful planting of seeds, the watchful care for and timely cultivation of growing plants, in the joyful harvest time, and in honest endeavor that mother earth shall not be starved into denial of her continuing abundance, there is for every day of the farmer's life not only incentive to a clearer knowledge of nature, but abounding opportunities to know if he will. To offer some measure of aid to the better understanding of our soils; to promote a careful study of the condition of lands under cultivation, and of the best methods to maintain their productiveness; to suggest methods for the restoration of fertility while it is yet comparatively easy; and to plead for the saving of such lands as are rapidly going to waste, are the objects of this publication.

For the purposes of the present discussion, soils may be roughly classed as *soils in place* and *soils transported.*

SOILS IN PLACE are the result of the disintegration of rocks by mechanical and chemical agencies,—changes of temperature, frost, rain, etc.,—the mass of earth so formed remaining in place, resting upon the parent rock. Only upon the summits of ridges are to be found soils which are simply the result of alteration of the underlying rock, and can be strictly called *soils in place;* but there are large areas which are usually classed as such because nearly alike in origin and manner of formation and to a very small extent mixed with the debris of other rocks. Such are the areas indicated upon the accompanying map and described in this bulletin as the dolomite lands, the shale lands, the sandy lands of East Tennessee, the lands of the Cumberland plateau, etc.

Soils Transported are made of a commingling, to a greater or less extent, of the materials derived from disintegrated stratified as well as crystalline rocks, carried off by flowing waters and laid down under varying conditions at a distance from the parent rocks. Such are many of the areas of valley and riparian soils of East Tennesseee, much the larger part of Middle Tennessee, and all of West Tennessee.

Soils in Place, both as to their mechanical condition and their chemical constitution, owe their characteristics to the parent rocks, so that the peculiarities of such soils can be more or less accurately understood when the kind of underlying rock is known. Soils Transported are remotely comparable with the rocks which underly them, and are the offspring, so to speak, of such heterogeneous ancestry as to make it in all cases difficult, and in some cases impossible, to class them with reference to rock parentage.

Whatever the kinds of rocks, the purely mechanical changes, disintegration, not accompanied by chemical changes, decomposition, result first in what is denominated, in the analyses hereafter described, "insoluble residue", or, to use a less accurate general term, "*sand.*" This insoluble residue is that part of the soil which represents the fragments of the original rock which do not easily yield to the active reagents of the chemist, and may be regarded as the frame work or skeleton about which are assembled and held together the other constituents of the soil body. But the disintegration of rocks is accompanied by certain chemical changes, by which the alkaline silicates are decomposed, broken up and readjusted, so that certain portions of the rock constituents are readily attacked by the reagents of the chemist and smaller portions are made easily soluble in soil waters. A residue is then left, the *clay*, one of the prime elements in the physical constitution of the soil. With the varying proportions of clay and sand, soils vary in character from the heaviest to the lightest: and vary still further because of the condition of the clay constituent, this condition depending upon the presence of a third indispensable element of every soil capable of sustaining plant growth, namely, *lime*; and that the lime shall be dissolved in water charged with carbonic acid, the acid derived in small measure from rain water, but more largely from the oxidation of *humus*, a fourth prime element of the soil.

The proportions in which these four prime elements, *sand*, *clay*, *lime*, and *humus*, are united determine the qualities of the arable soils. To maintain the proper physical condition of an arable soil, the solution of lime in carbonic acid is necessary to secure the coagulation of the colloidal clay and its retention in place among and around the particles of sand. The constant production of carbonic acid is therefore necessary, and this depends upon the presence of humus and its continuous oxidation. "The organic matter of the soil is constantly undergoing change; the debris of vegetation, leaves, the stubble and roots of crops removed, are the prey of legions of insects, cryptogams, bacteria, which so alter these materials as to make them soluble in the alkalies, converting them into humates, and these by other organisms converted into the simpler forms, soluble in water, and so made ready to re-enter upon the building of the cell growth of new vegetation." (Deherain.)

The soil is not a mere mass of inert, dead matter, but a theatre of ceaseless activities,—a wonderful combination of mechanical, chemical and vital energies,—of agencies destructive and reconstructive—of an ever repeated cycle of death and of resurrection.

Soils in forest or prairie, unaltered by the influence of man, are, as to their mechanical as well as chemical constitution, in every way best adapted to the healthful growth of the vegetation found native thereon. If it may be possible in any way to maintain a virgin soil in as perfect condition as we find it, we may easily enjoy all the "fruits of the earth" with almost as little labor as was demanded of Adam in his first home; but this is as improbable as is a return to the innocence and blessedness of Paradise. But we may realize, in some measure, a Paradise Regained. Who will labor with brain as well as body, with heart and head, doing what is prompted and directed by right thinking, may approach the beauties, and enjoy much of the happiness, of the garden which "the Lord God planted eastward in Eden."

In this wonderful laboratory, the soil, there are great stores of material more or less ready for immediate use as food for plants, and vastly larger stores which wait the changes which must come to make them fit for a like purpose.

Beside the fragments of the parent rocks, the residual clays, the lime salts resulting from the decomposition of such fine particles as have yielded to chemical changes, and the partially decayed organic matter—the four prime constituents of an arable soil,—there are in all soils, in combinations more or less stable, or in a condition of solubility in water, some or all of the following: potash, soda, magnesia, oxide of iron, phosphoric acid, sulphuric acid, constituents usually determined in a chemical analysis; and in most soils chlorine and manganese, as well as fluorine and boron.

Of these last four, fluorine and boron are found in such exceedingly small quantities, rarely more than a trace, that they are not ordinarily included in a chemical analysis. Chlorine is found in nearly all plants, and is considered an essential element; when found in excess as a constituent of the soil, either naturally or by artificial addition, it is harmful to many cultivated plants; such excess rarely occurs in any arable soil, and chlorine is not usually included in a chemical test. Manganese found in most soils, occurring only as an oxide, has, so far as known, no special office in plant nutrition. With the exception of chlorine, we shall have no concern with the elements here named.

That our readers may understand the meaning of the chemical and mechanical analyses hereafter presented, it is proper to define as clearly as may be the terms used.

The analyses of the type soils of Tennessee were made by J. B. McBryde, of this Station, using for the purpose that part of the soil made up of particles less than 1 millimeter in diameter, the coarser material having been first removed. The per cent. of gravel larger than 2 millimeters, and of fine gravel larger than 1 and less than 2 millimeters in diameter, is stated in each case.

1. INSOLUBLE RESIDUE includes the unaltered fragments of the rocks from which the soil was produced, such as do not yield readily to the methods usually employed by the chemists to separate the constituent elements. This insoluble residue does undergo alterations, gradually yielding up its constituents, but so slowly that a long series of years may pass without the occurrence of more than a trace of increased solubility. Its quality as an ingredient of the arable soil depends upon the fineness or coarseness of the particles, and their arrangement.

2. SOLUBLE SILICA is that portion of the residue of a soil, after digestion in hydrochloric acid, which is soluble in a boiling concentrated solution of sodium carbonate, and is supposed to represent the silica which may become slowly soluble in the soil waters and so enter into the sap circulation of plants.

3. POTASH, determined as potassium oxide. This is found in all soils in very different states, and is an essential of all plant food. These salts, combined with humus material or with the hydrated silicates, are very soluble, and do not for that reason accumulate in large quantities in soils exposed to such heavy rainfall as occurs in Tennessee. It must be kept in mind that the potash stated in the analyses means the total of potassium oxide found, which is twenty to twenty-five times as much as is in the water soluble state as an available element of plant food. But the percentage stated in the analyses may be regarded as a supply in reserve which, under favorable conditions, may be drawn upon for plant nutrition.

4. SODA, determined as sodium oxide. Found usually in our soils combined with silica, rarely as a chloride. "Though closely related to potassium chemically, sodium cannot be substituted therefor in plant nutrition," a fact which needs to be remembered when purchasing fertilizers or fertilizer materials.

5. LIME, determined as calcium oxide. A necessary plant food in itself, but even more important because of its influence upon the mechanical condition of the soil, in the processes of nitrification, and in the formation of the soluble carbonates. As already stated, lime is one of the four prime essentials of an arable soil; its absence in sufficient proportion is quickly followed by sterility.

6. MAGNESIA, determined as magnesium oxide. Found in all the type soils of the State, as a carbonate or silicate. "Of little importance as a plant food" (Wiley). "An indispensable plant food" (F. W. King). Mr. King states that magnesia collects more largely in the seeds of plants than lime, wheat containing in its ash 12 per cent. of magnesia against 3 per cent. of lime, &c., &c. "No plant can be brought to maturity if magnesia is absent" (E. A. Smith). However this may be, it is certain that dolomite (magnesian limestone) soils are much more easily injured by working when too wet than the soils in which magnesia is less prominently a constituent; and it is also a fact that dolomite soils readily and happily respond to an application of lime from a high grade calcium carbonate.

7. IRON, determined as ferric oxide. Though required in very minute quantities, it is absolutely indispensable; found in all soils, the red and yellow colors of which are due to the presence of iron. If present as ferrous oxide, as is sometimes the case, particularly

in the subsoil, it is injurious to plant growth; the remedy is by thorough working and airing the subsoil by use of the subsoil plow or by underdraining.

8. ALUMINA, determined as aluminum oxide, the characterizing constituent of common clay, which consists of exceedingly small particles of pure clay mixed with silica, iron, lime, carbonaceous matter, &c.

9. PHOSPHORIC ACID, determined as phosphorus pentoxide. Occurs in the soil in combination with various bases as phosphates of lime, of iron, of alumina, &c. Though found in all soils, it is seldom abundant, and is one of the ingredients of the soil most likely to be exhausted.

10. SULPHURIC ACID, found in very small quantities even in the most fertile soils, as sulphates of lime, potash, soda, etc.; sometimes as sulphide, and in organic compounds. Sulphates are easily soluble and are readily washed out into the off-flow of water into the underground channels. Sulphur is an essential part of organic compounds, both vegetable and animal.

11. VOLATILE MATTER is determined by heating the dried soil to a dull red heat until all the organic matter is driven off, and includes the water of combination, ammonium salts, &c., frequently contained if carbonates are present in the soil.

12. MOISTURE is determined by heating, cooling and weighing at intervals till constant weight is found.

13. HUMUS is partially decayed organic matter, whether vegetable or animal. Being a residue of organic matter of various origin, partially oxidized, its chemical composition is but imperfectly understood; but the fertility of an arable soil, in a climate such as ours in Tennessee, can not be maintained without an adequate supply of humus.

To use a homely illustration: A field of wheat ever so plenteous in yield, will not feed a man until the grain is harvested, threshed, ground and baked into bread; just so we may be sure that a given soil contains large stores of the elements of plant food, and yet be forced to acknowledge it as unproductive, because these stores are not available for the use of such plants as we desire to grow. The presence of one and all of the constituent elements is the first essential; but the proper condition of the soil as to its mechanical condition is equally essential. We shall find that even the least fertile of natural soils has a large supply of food elements, if not in the right condition for plant sustenance, nevertheless in such condition that right management will make possible a fair reward for well-directed efforts. The farmer is most directly concerned as to the mechanical condition of the soil, and to this he must give most of his thought as he must give most of his labor.

"A systematic separation of soils into classes of particles cannot fail to reveal a definite correspondence of mechanical composition to soil properties. The production of a crop is the result of certain functions, chief among which are temperature, moisture and plant food. In a given soil the temperature is markedly fixed by its physical state. The circulation of moisture in the soil and its capacity to be held therein, are chiefly functions of the state of aggregation of the soil itself. The availability of plant food in a soil is not measured by its quantity alone, but rather by its state of sub-division. It is not, therefore, a matter of surprise that the fertility of a soil is found, other things being equal, to be commensurate to a certain limit with the percentage of fine silt and clay which it contains." (Wiley.)

The mechanical analyses of the type soils which are discussed in this bulletin, were made by Prof. Milton Whitney, Chief of the Division of Agricultural Soils, U. S. Dept. Agr. The method used was that of Osborne, with such modifications as were suggested by extended experience in such work. The analyses made by Mr. Whitney are of the subsoils of the fifteen type soils, and were made directly from the original samples taken in the manner hereafter described. The results are very carefully set forth in the tabular statements, and are in themselves proof of the great value of such investigations.

In taking a sub-sample of the original material, the whole sample was thoroughly mixed; roots and litter that could be readily picked out by hand were thrown away. Gravel and stones were separated by passing the material through a brass sieve with circular holes 2 millimeters (about one-twelfth inch) in diameter; these stones were washed, dried and weighed, and the weight deducted from the original weight of the sample, and the percentage of coarse gravel calculated. The portion which passed through the 2 millimeter sieve is called "fine earth," and was used for the mechanical analysis.

An analysis of a soil which is not typical and so representative of a considerable area, is of little value. If the sample is taken from a locality carefully selected as fairly representative of the lands of like origin and like conditions, and evidencing like characteristics as shown by the peculiar kinds and like development of vegetation, we can reasonably assume such a sample to be typical. The types described in this bulletin were chosen after a most careful study of the various fields of observation, and are believed to be as nearly typical as can be obtained.

The illustrations were prepared from photographs taken at the time the samples were obtained, and are given to show the visible above-ground characteristics of the several localities.

The type samples of the soils of this State were taken in the following manner:

Boxes of uniform size, the inside dimensions of which are length 36 inches, width 4 inches, depth 3 inches, were provided with closely fitted tops put on with screws. At the place selected a pit was dug, three or four feet square and three and a half feet deep. On one side of the pit most free from roots was marked and cut out a prism of the earth to fit the box as accurately as possible. The box was then pressed on the prism, and with a long knife, or other convenient tool, the earth was cut in slantingly from both sides, leaving a roof-shaped ridge projecting above the rim of the box. This projecting portion was shaved off, and the lid screwed on. The soil prisms thus obtained show the soil, sub-soil and under-stratum to an exact depth of three feet, every particle of earth remaining in its original position with respect to the whole mass. The samples were taken in duplicate. At the same time samples of the soil proper, and of the sub-soil in each locality, were secured, also in duplicate.

ON BLACK OAK RIDGE, KNOX COUNTY. TENN.

NO. 1. KNOX DOLOMITE—Upper measures. Soil 0—8 inches; subsoil 8—16 inches.

LOCALITY—Woodland next southeast of orchards and vineyards of Wm. Jenkins, on Black Oak Ridge, 6 miles north of Knoxville, Tenn.

UNDERLYING ROCK—Magnesian limestone, 5 to 15 feet below surface.

FOREST GROWTH—Hickory, black oak, post oak, chestnut, some white oak, sourwood (*oxydendrum arboreum*), etc. Heavier timber, mainly post oak and black oak, removed some years ago.

USUAL CROPS UPON SIMILAR SOILS—Wheat, corn, the grasses.

In this case the soil proper was taken to a depth of 8 inches. A change of color and a well marked difference in texture indicated the line of distinction between the 8 inch layer and the sub-soil. The sample of sub-soil was taken to a further depth of 8 inches. Sixteen inches below the surface all appearance of color due to decaying vegetable matter was lost, the characteristic red clay mixed with a large proportion of chert forming the 20 inches of under-soil included in the prism taken at this point. The chert is quite uniformly distributed in the first 16 inches, the flinty fragments quite hard. Below 20 inches the chert is frequently found so soft as to break into smaller fragments between the fingers with slight effort. The hard surface chert is gradually broken down by the alternations of moisture and temperature, ultimately falling down to a rather fine sharp gravel.

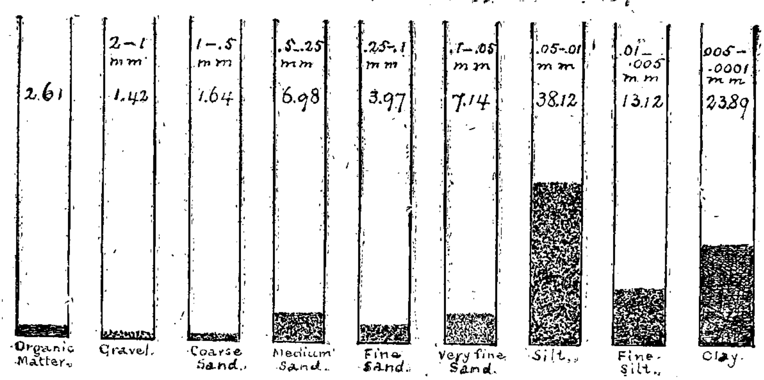
ANALYSIS OF SOIL No. 1.—Magnesian Limestone (Dolomite).

Insoluble Residue	84.985	
Silica soluble in Na_2CO_3	4.720	89.705
Potash, K_2O		0.120
Soda, Na_2O		0.112
Lime, CaO		0.053
Magnesia, MgO		0.140
Ferric Oxide, Fe_2O_3		1.318
Alumina, Al_2O_3		3.997
Phosphoric Acid, P_2O_5		0.040
Sulphuric Acid, SO_3		0.009
Volatile Matter		2.933
Moisture		1.733
Humus 1.010		

Original sample contained—

Gravel 25 to 2 mm diameter	16.66
Fine Gravel 2 to 1 mm diameter	2.24
Fine Earth less than 1 mm diameter	81.10

EXTURE OF MAGNESIAN LIMESTONE (DOLOMITE). SOIL, UPPER MEASURES. KNOX COUNTY, TENN. — 1–710.



AT LYONS VIEW, KNOX COUNTY, TENN.

NO. 2. KNOX DOLOMITE—Lower middle measures. Soil 0—8 inches; sub-soil 8—16 inches.

LOCALITY—Woodland, 500 yards north of E. T. Asylum for Insane, 5 miles southwest from Knoxville. Surface had been cleared of underbrush, lightly scarified with a cultivator, and sown to mixed grasses; otherwise a virgin soil. The catch of grass was not a good one.

UNDERLYING ROCK—Magnesian limestone, 8 to 15 feet below surface. Here the underlying strata dip southeast about 17 degrees, and are mixed with irregular bands of chert in various stages of disintegration.

FOREST GROWTH—White oak, black oak, several varieties of hickory, chestnut oak, post oak, dogwood, etc. A few large trees stand as reminders of the splendid timber growth of earlier days.

USUAL CROPS UPON SIMILAR SOILS—Wheat, corn, the pasture and meadow grasses all do well. Lands in the immediate vicinity, twenty to forty years cleared, wherever well cared for, yield satisfactory crops.

The accompanying illustration accurately exhibits the present condition of very large bodies of timber land, not only upon this magnesian limestone formation, but everywhere throughout East Tennessee. In this locality some effort has been made to protect the new growth of trees and to secure a carpet of grass in place of weeds, briars and worthless brushy undergrowth. Fields near by, cleared from forest like that which once grew here, are disfigured by barren spots, with here and there a broad expanse apparently abandoned as unproductive. Save where marked with deep chasms, as is too frequently seen upon the steeper slopes, not one of a hundred acres of these worn dolomite lands is past recovery under careful management.

ANALYSIS OF SOIL NO. 2.—Magnesian Limestone (Dolomite).

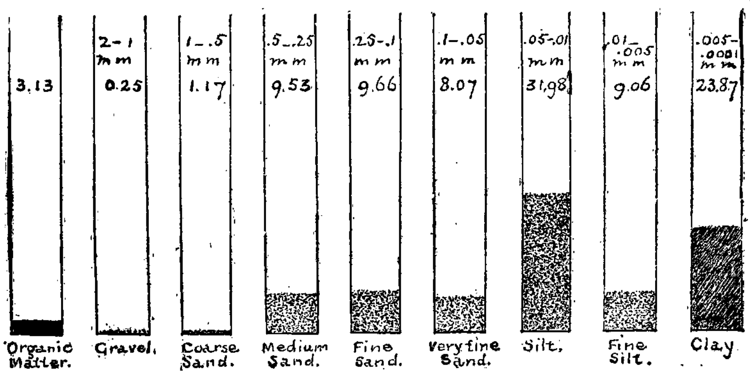
Insoluble Residue	80.197	
Silica soluble in Na_2CO_3	5.478	85.675
Potash, K_2O		0.180
Soda, Na_2O		0.114
Lime, CaO		0.060
Magnesia, MgO		0.213
Ferric Oxide, Fe_2O_3		2.113
Alumina, Al_2O_3		5.205
Phosphoric Acid, P_2O_5		0.074
Sulphuric Acid, SO_3		0,014
Volatile Matter		3.900
Moisture		2.350

Humus 1.490

Original sample contained—

Gravel 70 to 2 mm diameter	22.79
Fine Gravel 2 to 1 mm diameter	2.05
Fine Earth less than 1 mm diameter	75.16

TEXTURE OF MAGNESIAN LIMESTONE (DOLOMITE) SOIL, LOWER MEASURES. KNOX COUNTY, TENN.—2-7-12.



Climatological Data, March 1, 1871, to June 1, 1897.

KNOXVILLE, TENNESSEE.

	Av. mean temperatnre deg. Fah.	Av. rainfall inches		Av. mean temperature deg. Fah.	Av. rainfall inches.
March	47.	5.54			
April	58.4	4.93			
May	66.2	4.03	Spring	57.2	14.50
June	74.	4.12			
July	76.5	4.43			
August	74.9	3.96	Summer	75.1	12.51
September	69.2	2.63			
October	57.7	2.70			
November	47.	3.79	Fall	57.9	9.12
December	40.	4.03			
January	34.	5.38			
February	42.3	5.33	Winter	39.1	14.74

Average annual rainfall, 26 years, 50.92 inches.

During the period of 26 years, the smallest rainfall was during the year beginning March 1, 1894, and ending February 28, 1895, 34.94 inches; the largest rainfall was during the year beginning March 1, 1874, and ending February 28, 1875, 66.91 inches. It is merely a curious coincidence that the mean of these two extremes is the average annual rainfall during this long period.

An inspection of the foregoing tables shows very plainly a close resemblance between these soils, No. 1 and No. 2. Taken from localities many miles apart, they are close akin, because of like rock parentage. The differences, though slight, are no more clearly indicated by the visible above-ground characteristics than they are by the results of chemical and physical analyses.

Under ordinarily fair conditions, our cultivated plants can and do obtain the greater part of their food from the stores contained in the upper twelve inches of the soil; but for reasons well understood, what is usually called the soil proper, even of fresh lands, is the upper six or eight inches of earth. Only the best farmers in Tennessee ever plow six inches deep; and upon old land, nine-tenths of the work of breaking plows does not exceed an average depth of five inches.

These soils are properly classed as heavy clays, and when new as clay loams. The average weight of such soils to a depth of eight inches, is approximately 1,200 tons per acre. The analyses of the two soils may be stated thus:

	No. 1.	No. 2.
Coarse matter, gravel	453,600	596,160 lbs
Insoluble Residue, less than 1 mm diam . . .	1,652,108	1,446,754 "
Soluble Silica	91,871	98,804 "
Potash	2,336	3,246 "
Soda	2,180	2,056 "
Lime	1,030	1,082 "
Magnesia	2,721	3,843 "
Iron Oxide	25,622	38,114 "
Alumina	77,709	93,889 "
Phosphoric acid	778	1,335 "
Sulphuric acid	175	232 "
Volatile matter	70,392	93,600 "

From the mechanical analysis we find that of silt and fine silt taken together, the proportion in No. 1 is 51.24 per cent.; in No. 2, 40.04 per cent. In No. 1, the proportion of "clay" is 23.89 per cent., and in No. 2, it is 23.87 per cent.

Recent investigations of the results of soil analyses appear to indicate, that only such parts of a soil that are of less than .05 millimeter in diameter should be considered in a chemical test, because of the rapid decrease of acid-soluble matter in the coarser sediments. Of the soluble matter found in that part of the total weight of the samples which passed through the 1 millimeter sieve, probably three-fifths or more is found in the "clay," and nearly two-fifths in the silt and fine silt, the remainder in the coarser materials so small as to be, for all practical purposes, a negligible quantity.

The average diameter of the particles of "clay" stated in the tables as .005 to .0001 mm., may be taken as .00255 millimeter. (Whitney.) These particles are so small that 10,000 of them can be placed in contact upon a line one inch long. If we could spread out one pound of soil No. 1 in a single layer of particles in contact, they would occupy an area of 325 square yards,—the clay particles 269 square yards, the silt and fine silt 49 square yards, and the remainder 7 square yards. In this pound of soil there are more than one hundred thousand million of particles of clay; more than eight thousand million of particles of silt. It is difficult to comprehend this plain statement of the immense number of grains composing a soil, and that each one of these grains is a separable unit, nearly or wholly surrounded by water or air, or by both. The finer the grains of a soil the larger the space in which water may be held, ranging from 20 to as high as 65 per cent. in the soils named in this bulletin, and in this particular class of soils about 45 per cent. The finer the grains of soil, the less permeable for water; the larger the proportion of clay, the greater the space for water, and the more slowly it gives it up by percolation.

In their natural condition these dolomite soils are highly fertile: the facts already stated show why. Texture, plant food elements in kind and in proportion, are of the best, and the average climatic conditions are altogether favorable.

Just as soon as we clear the land for cultivation, we begin to introduce new conditions—to interfere, not always wisely, with the methods of nature. As stated in the outset, the endeavor should be to control and direct our necessary interference, so as to preserve, as far as we can, the physical conditions of the virgin soil, and to conserve the stores of plant food therein contained.

The best and most productive cultivated lands of the magnesian limestone areas, are those which most closely resemble in color, texture and in all ways, the soils of the forest lands about them. These best lands are porous, because of the fineness of their constituent particles, the sufficient proportions of silt and clay, and their arrangement within the soil, the coarser material of such kind and so intermixed in the soil as to be continually acted upon by the soil waters and made to contribute slowly, but surely, to the increase of available mineral plant food. So long as the coarser sand and fragments of chert are mixed together, as in the natural soil, its permeability is nearly that of the finer particles, the lands are rarely injured by excessive rainfall, and the crops suffer less during long periods of drought.

Not only the soil, but the sub-soil and the under stratum, are sufficiently porous to permit of the ready escape of surplus waters into the deeper strata, while retentive enough to prevent the rapid leaching of soluble plant food elements: the arrangement of soil particles is such as promotes capillarity, by which the store of water below is brought toward the surface and within the reach of the rootlets of the plants when needed. So long as these physical conditions subsist, and a supply of organic matter is maintained, generous crops may be confidently expected, even in such years as 1878, 1889, and 1894, when well-kept lands upon the dolomite ridges and slopes of East Tennessee rewarded careful farmers with fairly abundant crops of corn, while neighboring fields, improperly managed, made pitiful returns.

The limits of this bulletin do not permit a full discussion of methods to maintain these soils in their best condition, nor of methods for restoration of fertility. Means and ways necessarily vary. No two contiguous farms, nor fields, nor parts of fields, can be treated alike. There can be no cure-all sort of prescription for the run-down farms, no more than for the run-down farmer.

How many hundreds of years must have passed, during which well-ordered natural forces have been preparing these soils, grinding down the rocks into such fineness as has been described, and clothing the surface with forest growth, we can only conjecture. In how few years it is possible that unwise conduct, heedless ignorance, or wilful neglect may change a land of plenty and beauty into a barren waste, unsightly and forbidding, can be learned without search into ancient history. Thousands of farmers whose hairs are not yet gray, can remember unbroken forests upon the hill sides, where now the lands are abandoned as worn out.

These dolomite soils are injured by plowing too wet, even more easily than the heavy clay lands of the limestone valleys of East and Middle Tennessee. Many years of continuous good management are necessary to undo the evils that come from breaking these soils over-wet at any season of the year. When this mistake is made in the spring, or early summer, the result is especially bad.

Cultivation of hoed crops at a uniform depth for several seasons and the resulting formation of a hard-pan, for obvious reasons objectionable even on level lands, is sure to bring disaster to these hill-side lands. Inquiry among observant farmers, from Sullivan county all the way to the Georgia line, verifies the opinion of the writer that nine-tenths of the gullies which disfigure the fields were primarily caused by an almost water-tight hard-pan.

The custom, now happily becoming less prevalent, of turning cattle upon the corn fields or upon the stubble of the annual crops, after harvest, keeping the cattle upon these fields as long as a mouthful of forage of any sort can be found by hungry animals, and thereafter leaving the fields bare, to be leached by the winter rains, is bad practice upon level lands, and doubly bad upon the slopes of East Tennessee.

Besides the losses of nitrogenous matters by the removal of the crops, and the probably greater losses by unheeded, because unobserved, filtration into the depths during our winters of heavy rainfall, there is too prevalent a neglect of such plans of rotation as are necessary to renew the supply of humus material, without which a soil, ever so abounding in mineral constituents of plant food, is practically unproductive.

For many reasons, the hill lands of East Tennessee are very properly most highly prized. Nowhere should there be more careful study of the best methods to keep the soil in place. It is not a difficult matter to prevent surface-washing, even upon the steeper slopes of these cherty dolomite lands, if the plainest and simplest precautionary measures are adopted and promptly applied.

No man can decide when to plow or to cultivate his fields most effectively unless he *knows* his land, surface and under-soil, not to a depth of six or eight inches only, but three or four feet or more. The more accurate such knowing the more intelligently can he adopt the right ways to handle his soil, so as to husband the waters of our abundant rainfall, that the crops may suffer least from our occasional periods of spring and summer droughts.

What proportion of the "clay," which makes up nearly one fourth of the dolomite soils, is of such extreme fineness as to have the properties of pure clay, has not been determined. Our own experience upon the lands of the station farm has proven how easy it is to promote the accumulation of fine clay in an almost water-tight stratum at a depth of a few inches below the surface, and how difficult it is to break up and render friable the tenacious subsoil so formed. Referring to the physical analysis of soil No. 1, and to what has been said of the fineness of the grains of silt and clay, and of the immense aggregate of surface area of the soil particles, it is proper to state that it is by no means probable that the smallest of these particles are, in fact, invested by films of water. In natural soils, the finer particles are made up of complex grains. The extreme division effected by Mr. Whitney's methods of analysis, by which the compound grains are broken down, may rarely exist in a natural soil. The more nearly the actual soil approaches such divisibility of particles, the more rapid and complete may be the solubility of the mineral ingredients of plant food, provided such condition can be maintained. The better condition is that which allows of free movement of the soil waters.

These are usually called limestone lands; but the proportion o lime in the upper foot or two of soil is comparatively small; and this rapidly decreases as the lands are cultivated without manuring. Experience has proven that a dressing of 20 to 40 bushels of fresh lime, equal to 60 to 120 bushels of slaked lime, per acre, is followed by a great improvement in the physical characteristics of the soil, and thereafter by a very marked increase of fertility. The free use of superphosphates by many farmers on these lands, has, in every case, been followed by satisfactory results, due, without doubt, very much to the lime constituent of the fertilizers.

NEAR LENOIR CITY, LOUDON COUNTY.

No. 3. LENOIR LIMESTONE. Soil 0—7 inches; Subsoil 7—14 inches.

LOCALITY—Woodland, 1½ miles northeast from railway station, Lenoir City, Loudon County, on lands of Geo. M. Burdette.

UNDERLYING ROCK—Blue limestone (Lenoir), the *Maclurea* limestone of Safford. Lower strata quite hard and compact, upper strata shaly and weathering easily.

FOREST GROWTH—White oak, hickories, poplar (*liriodendron*), walnut, elm, persimmon, hornbeam, dogwood, sourwood, etc.

USUAL CROPS.—Corn, wheat, all the grasses of this region. A fertile and durable soil.

In physical character and in composition closely resembling the limestone lands of Rutherford, Wilson and Williamson Counties in the Central Basin of the State; varying somewhat as the soil is derived from the differing strata of this series of formations. The locality selected for the type sample furnishes a fair representative of this class of soil.

ANALYSIS OF SOIL NO. 3.—Lenoir Limestone.

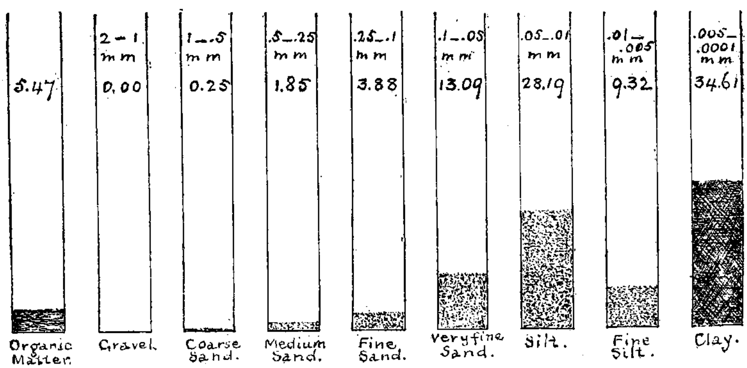
Insoluble Residue	73.128	
Silica soluble in Na_2CO_3	6.197	79.325
Potash, K_2O		0.330
Soda, Na_2O		0.171
Lime, CaO		0.180
Magnesia, MgO		0.342
Ferric Oxide, Fe_2O_3		3.012
Alumina, Al_2O_3		7.695
Phosphoric Acid, P_2O_5		0.104
Sulphuric Acid, SO_3		0.018
Volatile Matter		5.983
Moisture		2.350

Humus 2.150

Original sample contained—

Gravel 20 to 2 mm diameter	0.71
Fine Gravel 2 to 1 mm diameter	0.69
Fine earth less than 1 mm diameter	98.60

TEXTURE OF BLUE LIMESTONE (LENOIR) SOIL, LOUDON COUNTY, TENN.—3-714.



NEAR MADISONVILLE, MONROE COUNTY.

No. 4. KNOX SHALES. Soil 0—6 inches; subsoil 6—12 inches.

LOCALITY—Woodland, on farm of Rev. Jas. P. Kefauver, near Madisonville, Monroe County.

UNDERLYING ROCK—Shales, calcareous, with some irregular intercalated layers of earthy limestones. Upon the wider and more level areas of these lands, the underlying rock is found 4 to 6 feet or more below the surface; upon the slopes the rock is covered from 1 to 3 feet, in places exposed.

FOREST GROWTH—White oak, black oak, scrub oak, hickories, hackberry, black walnut, sassafras, etc.

USUAL CROPS—The cereals, pasture and meadow grasses.

These are valley lands, mainly. In Monroe County and adjoining districts, and in the wider valleys, the surface soils contain a larger percentage of lime than those of the same class farther northeast, and are, in the main, stronger and more durable. Here and there, especially in the narrower valleys, are found considerable areas, originally quite productive, but quickly exhausted because of the small depth of soil overlying the parent rock; again there are broad stretches where the processes of soil making have been less frequently arrested by the denuding floods, or have been reinforced by accretions from the hills and ridges of magnesian limestone or of blue limestone and marble lands, on the one side or the other.

ANALYSIS OF SOIL NO. 4.—Knox Shales.

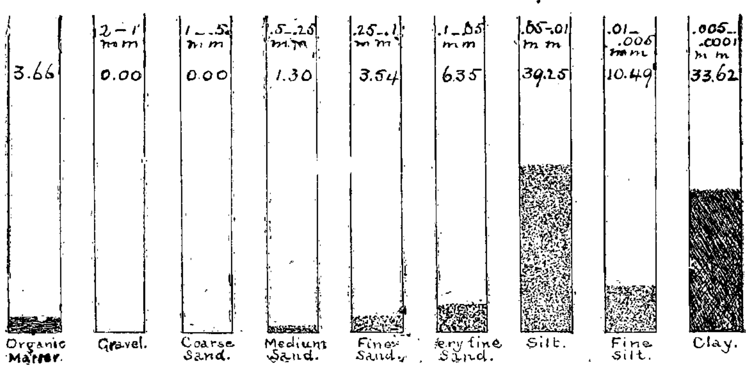
Insoluble Residue	76.875	
Silica soluble in Na_2CO_3	6.030	82.905
Potash, K_2O		0.312
Soda, Na_2O		0.101
Lime, CaO		0.163
Magnesia, MgO		0.455
Ferric Oxide, Fe_2O_3		2.706
Alumina, Al_2O_3		5.987
Phosphoric Acid, P_2O_5		0.057
Sulphuric Acid, SO_3		0,025
Volatile Matter		4.473
Moisture		2.093

Humus 1.360

Original sample contained—

Gravel 20 to 2 mm diameter	1.58
Fine gravel 2 to 1 mm diameter	1.70
Fine earth less than 1 mm diameter	96.72

TEXTURE OF SHALE (KNOX SHALE) SOIL,
MONROE COUNTY, TENN.—4–716.



The analyses, chemical and physical, of soils Nos. 3 and 4, appear to indicate that they are practically of the same agricultural value, capable of producing like crops, needing like treatment, etc. Examination of the lands themselves will show great differences. Both the shales and the limestones are valley-making rocks; but these underlying rocks are not only unlike in structure, but exist under very different conditions. The blue limestones (Lenoir) are often found at nearly the same angle of dip along a strike of many miles, the derived soils remarkable for the uniformity of characteristics, all the way from the lower levels of the valleys to the summits of the bordering slopes. The successive belts of fertile valley lands overlying the calcareous and argillaceous formations, including the various strata of blue limestone and of the gray and variegated marbles, afford soils of close likeness, slightly heavier and stiffer as we approach the northwest side of the greater valley of East Tennessee. Minor differences, due to the varying dip of the strata and to the differing proportions of shaley intermixture, with here and there glady places, due to the out-crop of highly tilted rocks, serve to emphasize the generally uniform character of these soils, all the way from the Virginia to the Georgia line.

The shales (Knox) from which have been formed the soil No. 4, are found at all angles and often much contorted, frequently twisted and folded at a greater or less angle to the general line of strike. The outlines of these shale valleys are very irregular. Made up of material of varying character, the laminae of the strata differing in the proportions of clay and sand, and in amount of contained lime and iron, in places slaty and strongly resistant to disintegrating forces, and again soft and readily weathering down upon exposure, these soils are rarely found of like consistency or even like surface appearance over any large field. In the wider of these valley ranges are lands very desirable, of good depth, and quite durable under good management. In the narrower and more uneven valleys the soil is mostly thin, barely hiding the underlying rocks, which have been deprived of their calcareous matter by leaching. The writer has found numerous small areas in the "poor valleys" quite as good as the best of these shale lands, producing good crops of corn, wheat and oats, and particularly well adapted to the meadow grasses. Because of the peculiar structure of these soils, great care is necessary to prevent the formation of an impervious subsoil, to be certainly followed by surface washing.

Besides the soils of which analyses are given, there are considerable areas, mostly hill lands, overlying and derived from the rocks to which Dr. Safford has given the appropriate name, Iron Limestone. Consisting mainly of a hard, dark gray, highly ferruginous sandy, fossiliferous stone, weathering into a soil of a strong red color, these Iron Limestone lands are among the very best for the growing of orchard and small fruits, and for all kinds of garden truck. As population increases, and there is greater demand for all the fruits adapted to this climate, the value of these red hills will be better understood.

IN KNOX COUNTY.

Still another class of soils, closely related to those of the Iron Limestone, of no great extent, but important because of their proximity to river and railway transportation, are those resulting from the disintegration of the silicious red shales and the associated crinoidal marbles. These almost blood-red lands, which attract the attention of everyone who travels about the vicinity of Knoxville, are naturally very fertile. Usually occupying rather flat ridges of little width and no great length, these were among the earliest lands cleared and cultivated. Unfortunately, too many of these once beautiful hill tops and slopes have been neglected, and now stand as warnings to the farmers of to-day, that they "mend their ways" lest the same fate befall their own homes. The accompanying illustration is given because it is far more eloquent than any words of admonition or appeal. When this land was new every seed that was planted upon it brought return of twenty to more than a hundred fold. The land *was good.* It *can* be made as good as ever. The subsoil is there, clay and sand and lime, potash and phosphates, in plenty, but naked, cold, outcast, forgotten.

There are thousands of such evidences of continued neglect, which disfigure the surface of our state. In this particular case the work of restoration presents no serious difficulties, because there is a good foundation upon which to rebuild. Upon the less stable, silty lands, these ugly blots are more numerous, wider and deeper, demanding prompt and energetic measures to prevent further disaster.

NO. 5. SANDSTONE. Soil 0—6 inches; subsoil 6—12 inches.

LOCALITY—Chestnut Ridge, on land of John Alexander, 5 miles southwest from Fullens' Station, Greene County.

UNDERLYING ROCKS—Sandstone (Chilhowee), 3 to 7 feet deep.

FOREST GROWTH—Chestnut, black-oak, sourwood, etc.; undergrowth, dwarf oaks, scrub pines, chinquapin, etc.

USUAL CROPS UPON SIMILAR SOILS—Scanty crops of corn are sometimes grown upon these lands when new. These soils were regarded with little favor until the introduction of tobacco culture about 1885.

ANALYSES OF SOIL AND SUBSOIL NO. 5.—Sandstone.

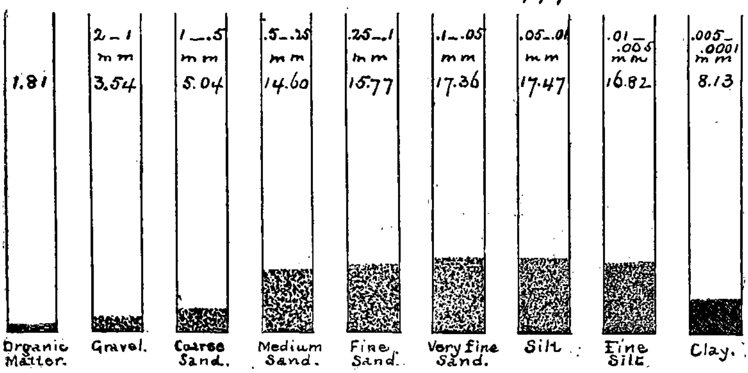
	Soil		Subsoil	
Insoluble Residue	89.896		91.995	
Silica soluble in Na_2CO_3	2.659	92.555	2.655	94.650
Potash, K_2O		0.092		0.055
Soda, Na_2O		0.054		0.033
Lime, CaO		0.050		0.046
Magnesia, MgO		0.085		trace
Ferric Oxide, Fe_2O_3		0.832		0.774
Alumina, Al_2O_3		2.185		2.301
Phosphoric Acid, P_2O_5		0.021		trace
Sulphuric Acid, SO_3		trace		trace
Volatile matter		2.833		1.366
Moisture		0.940		0.550

Humus 0.730

Original sample of soil contained—

Gravel 20 to 2 mm diameter 1.55
Fine gravel 2 to 1 mm diameter 3.35
Fine earth less than 1 mm diameter 95.10

TEXTURE OF BRIGHT TOBACCO (SANDSTONE) SOIL, GREENE COUNTY, TENN.—5-779.



It was for many years claimed that the finest grade of bright tobacco, every way as good as the world-famed product of North Carolina, could be grown in Tennessee only on the soils of a small territory not more than six miles square, the center of which was John Alexander's Chestnut Ridge field, the first cleared for the purpose. The success of the tobacco industry, now one of great importance in upper East Tennessee is due to the enterprise of this pioneer cultivator. The illustration above shows the characteristic undergrowth of these flat-topped sandy ridges. The locality

ON CHESTNUT RIDGE, GREENE COUNTY.

pictured is on the eastern border of the field upon which was grown the first crop of tobacco, the excellence of which was admitted in every tobacco market of the country. In the center of the picture is seen the kindly face of the white-bearded patriarch to whom is due the beginning of a new industry in this region. It is a mid-day scene, on the last day of August; the first of the soil prisms has just been taken from the pit; the jug of cider has refreshed the helpers, and the boys are "finishing off" off a water-melon.

The next picture shows the log cabin homes of two of the mountaineers who proffered their assistance in digging. The small trees and most of the underbrush have already been cut away for domestic use and for "firing" in the barns; the larger ones are "deadened" in readiness for the clearing of an extension of the tobacco field. The best bright tobacco must have new lands. After the second year, or at most the third, the land is devoted to corn, oats, and frequently to wheat. Never again can the finest tobacco be grown upon these soils. A good yield of fairly good quality can be obtained after two or three years of other crops; but nevermore such as the first crop.

ON CHESTNUT RIDGE, GREENE COUNTY.

Upon these sandstone ridges and upon the mountain side in full view a few miles away, are apples the like of which cannot be grown upon any of the more fertile lands of the valleys further northwest.

For the growing of tobacco it is necessary to use commercial fertilizers upon the newly cleared land, else a meager yield must satisfy the farmer. For this purpose a complete fertilizer is preferred, rarely more than two hundred pounds per acre.

The culture of tobacco has extended throughout this region, and is now pursued with profit upon soils of nearly similar character from the northern border of Sullivan county to Sevier, and is making its way further southwest. Probably a good leaf can be grown upon choice areas of the Knox and Rome sandstone as well; but the careful man will endeavor to select such as approach most closely to the characteristics of the type here presented. It will be observed that the "clay" of this soil is less than ten per cent., and that the soil is composed largely of the medium grades of sand. "Investigations have been made of the amount of water contained in these soils, and it has been found that the most favorable growing conditions are where the soil has between 6 and 8 per cent. of moisture. When the soils contain more than 10 per cent. of moisture they are too wet for the crop, and the plants are inclined to be coarse textured and dark colored. When soils contain less than 5 per cent of moisture crops suffer. If the deficiency is not too marked, the plant has a finer texture, and a brighter color can be given in the curing, but while the quality is thus improved the yield per acre is very much less: it is then a question whether the increased value of the crop per pound compensates for the smaller yield per acre." (Whitney). Here is an explanation of the reason why new lands must be cleared for the production of the higher grades of bright tobacco. In the virgin soil of the Horse Creek section the finer sand and silt are found in larger proportion in the soil than in the subsoil, and as we go down the relative proportion of clay increases; at a little more than twenty-four inches, as was found in taking this particular type sample, the soil becomes quite heavy and compact. In its natural condition under-drainage is sufficient to prevent the accumulation of soil water at too high a level, while the fineness of the particles of the soil proper is such as to retain moisture sufficient for the needs of the crop. The growers of fine tobacco in this region do not have much dread of the bad effects of a "dry spell" upon a first crop, even if such a season does come, after the stand of plants is secured; about the crop of the second year there is more anxiety. The various operations of tillage have the ultimate result of so changing the physical character of the soil, not alone of the few inches actually stirred by the plow and other implements, but of the under stratum also, that the proportion of moisture contained is considerably larger than in the new land. To this larger capacity for moisture, much more than to the unexpended residue of fertilizers applied to the tobacco crop, is due the well known fact that the crop of corn or wheat following tobacco is a better one than would have been produced upon the newly cleared lands.

Climatological Data, March 1, 1879, to June 1, 1897.

CHATTANOOGA, TENNESSEE.

	Av. mean temperature deg. Fah.	Av. rainfall inches		Av. mean temperature deg. Fah.	Av. rainfall inches.
March	50.7	6.12			
April	61.3	4.50			
May	68.3	4.07	Spring	60.1	14.70
June	75.2	4.71			
July	77.8	4.14			
August	76.1	4.06	Summer	76.4	12.91
September	70.9	3.68			
October	60.4	2.60			
November	50.1	4.07	Fall	60.4	10.35
December	43.5	4.29			
January	40.7	6.11			
February	45.8	5.55	Winter	43.3	15.95

Average annual rainfall, 18 years, 53.69 inches.

The table above is made up from the records of the Weather Bureau, and shows the averages at Chattanooga for 18 years. Such records become more valuable as they cover longer periods. They are not printed in this bulletin to induce any one to think that it is possible to foretell what is going to be the amount of rainfall this autumn, or whether we shall have an open winter or one of unusual severity. We shall never be able to predict the weather more than two to four days in advance, and then with moderate probability. Nevertheless the study of such data will be a great help to every farmer in many ways.

There are farmers in the Chattanooga district who remember the dry spring of 1879, and how the drought ran on into July. Corn was scarce that year. The fall of 1879 was just dry enough to permit the best preparation for the seeding of wheat; but the winter was warm, with an average rainfall. The wheat plants grew all winter, and there was much discussion as to the advisability of pasturing off the heavy growth. A warm spring followed, with a rainfall of nearly twenty-nine inches from March 1 to June 1. There was a big crop of straw, but the small yield of grain was shrunken by the hot dry spell late in May and early in June. Here were two abnormal spring seasons. Again in 1885 there was a dearth of water from the middle of January until the middle of May, and prospects were blue; but the later rains came, and a good crop was made. Now the facts are, that during the 18 years covered by the observations at Chattanooga there have been only three dry spring seasons, one of which was not serious; two summer droughts, in 1883 and in 1894, the latter not very severe; only one fall season so dry as to make plowing very difficult; and one winter which will be remembered as the dry winter before the great wheat crop of 1897. These are the only very marked departures from the normal weather conditions during the 18 years.

It is well to know the facts which have been gathered with so much care by the observers of the Weather Service. We can look backward, and with these records before us, recall the history of our successes and our failures, and see quite clearly that even during the most unfavorable seasons, we might have managed better, and so have suffered less.

The climatological data given in this bulletin tell us what may *probably* occur; and enable us to decide intelligently what is probably best to be done. We may assume the figures in the tables as normals, representing as they do the average distribution of rainfall for a period of a quarter of a century. The departures from these normals were not the only adverse conditions, but were in every instance the most potent in causing the failures or partial failures of our crops.

Can we manage in any way to mitigate the severity of droughts or to lessen the evils of excessive rainfall? Just to the extent that we can restore our soils to the same physical condition as found in the virgin prairie or forest, the more certainly can we rest assured that the seed we sow shall bear fruit and our children not want for bread. Whatever methods are best to bring about such restoration are the ones to be adopted. The time when, the particular way, the implements to be used, must be determined each man for himself, for his own fields. In the East Tennessee country, where one can often find in a field of a half-dozen acres soils of various origin and diverse characteristics, there is need for most careful observation, prompt decision, and equally prompt action. There are big fields in this part of the State upon which can be grown staple crops by plantation methods, but upon nine-tenths of the lands there must be the watchfulness, thoroughness of methods, and attention to details, which distinguish the gardener from the ordinary farmer.

The lands already described as No. 3 and No. 4 will always be greatly benefited by fall plowing and by sub-soiling at intervals, especially if the furrows be thrown up in high ridges and so left till in proper condition for harrowing, or perhaps cross-plowing, for spring crops.

The cherty dolomite lands, No. 1 and No. 2, should be plowed early in the fall or in late summer, never when even a little too wet. In this climate we cannot be sure that winter frosts will undo the evils of plowing over-wet heavy soils, especially this particular class.

The sandy soils, No. 5, will not be at all benefited by fall or winter plowing.

The more frequently the blue limestone and shale lands are seeded down to clover or grasses the more easily can the proper physical condition be maintained. Wherever the farmer can do the work systematically and thoroughly, it will pay to underdrain his lands; this is especially true as to the shale soils.

Upon these two classes of soils, as well as upon the dolomite lands, moderate applications of lime at intervals of three to six years, are advisable in many instances. Wherever the land shows ground water in excess, lime should be used with great caution, if at all. A number of test holes may be dug, three feet or more deep, here and there in the field, and left open long enough to determine whether or not the ground water level is too near the surface, and so indicate the best modes of procedure to effect permanent improvement. This caution will apply to the heavy clay soils of some parts of Middle Tennessee.

Upon all these distinctive soils, and especially upon the shale lands many years under cultivation, it is good practice to harrow wheat and winter oats, the clover fields and meadows, early in the spring,—in February or in March, once, or even twice if opportunity permits,—when the surface is in the right condition. Our heavy winter rains make upon these soils a moisture-wasting crust, which must be broken if we will do what is best to guard against the May drought so much feared in Tennessee.

It would appear needless to remind the careful farmer that hoed crops, such as corn, sorghum, potatoes, &c., should be cultivated as soon after rains as the surface condition will allow, even though not a weed nor a sprig of grass shall appear in the rows of plants, and that it is bad practice to defer such cultivation until the surface soil is so dried out that a dust cloud follows the plowman across the field.

In short, the operations of tillage from beginning to end should be so conducted as to keep the soil fine; conserve moisture in the upper soil; promote the off-flow through the under soil, and not along the surface, of the excess of water; secure capillarity by preventing the formation of hard pan; reduce the losses of soil moisture by evaporation, by keeping the surface in such condition as to furnish an earth mulch, but not so fine as to become dust.

With these few suggestions, based upon the facts already recited, and in accord with the somewhat extended experience of the writer, we will leave the valley of East Tennessee and begin our journey westward.

NO. 7. SANDSTONE AND CONGLOMERATE OVERLYING COAL MEASURES—Soil 0—5 inches; subsoil 5—10 inches.

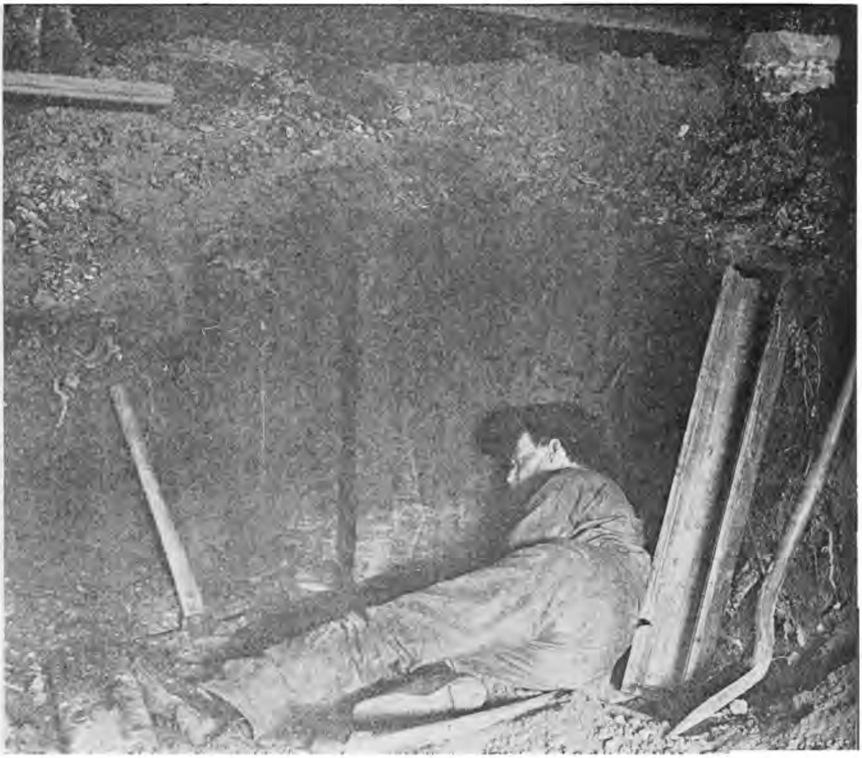
LOCALITY—150 yards S. W. from railway depot at Tracy City, Grundy County.

UNDERLYING ROCK—Sandstone, at depth of 2 to 5 feet.

FOREST GROWTH—Scrub oak and pines.

USUAL CROP UPON SIMILAR SOILS—Potatoes and vegetables; for second and all subsequent crops fertilizers must be used.

This type sample of the Cumberland plateau soil was taken under difficulties. Just as preparations had been made for the work and the locality chosen, there came a heavy rain, thoroughly wetting the soil so as to stop out-door operations for a day or more. A few yards away from the selected spot was a new frame house, the roof not complete, much of the siding yet to be nailed on, the floor all laid upon joists some two feet above the ground. Underneath this new house the grass was still green and growing. Upon request, the owner of the house allowed us to continue the work of cellar excavation already begun. The picture shows how this sample was secured. Thirty inches from the surface the sandy soil ran into a very soft sandstone easily cut with the rather dull knife with which the operator is shown squaring off the bottom of the prism of soil. Before and since the somewhat uncomfortable proceeding here illustrated, we have made diggings three to five feet deep in the plateau region, from Scott County to Bledsoe, and can present this Tracy City sample as fairly representative of four-fifths of the mountain lands. From the head



IN A CLOSE PLACE AT TRACY CITY, GRUNDY COUNTY.

waters of the many affluents of the Emory river northward to the Kentucky line, the depth of soil overlying the sandstone is somewhat greater than southward from Crossville, the court house town of Cumberland County, and the farms are more numerous and perhaps more fertile.

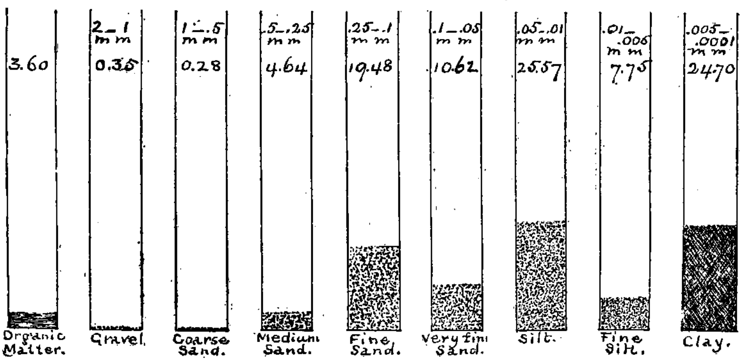
ANALYSES OF SOIL AND SUBSOIL NO. 7.—Sandstone of Cumberland Plateau.

	Soil		Subsoil	
Insoluble Residue	77.510		76.585	
Residue soluble in Na_2CO_3	7.370	84.880	8.180	84.765
Potash, K_2O		0.403		0.373
Soda, Na_2O		0.163		0.142
Lime, CaO		0.073		0.067
Magnesia, MgO		0.291		0.306
Ferric Oxide, Fe_2O_3		2.342		2.455
Alumina, Al_2O_3		6.091		6.631
Phosphoric Acid, P_2O_5		0.017		0.014
Sulphuric Acid, SO_3		0.012		0.014
Volatile matter		3.733		3.090
Moisture		1.660		1.683

Humus 0.805

Original samples contained—	Soil	Subsoil
Coarse gravel, 20 to 2 mm diameter	0.44	1.05
Fine gravel, 2 to 1 mm diameter	0.13	0.24
Fine earth less than 1 mm diameter	99.43	98.71

TEXTURE OF SANDSTONE (CUMBERLAND PLATEAU) SOIL, GRUNDY COUNTY, TENN.— 7–720.



The Cumberland plateau has an area of nearly three millions of acres, of which little more than one-eighth are included in the enumeration of farm lands. Because of the character of the soils, the difficulty of access, and the want of transportation facilities, these lands have been neglected. With the development of the coal-mining interests and the building of railroads across the territory, this section of the state must soon be more thickly populated, and the lands become more valuable. It was a common saying twenty-five years ago, that "the more mountain land a man owns the poorer he is." In those days the large tracts were used almost solely as a summer range for cattle and sheep from the valley farms. It was a common practice to set fires every year to destroy the undergrowth and "open up the pasturage." Nobody seemed to consider the timber of any value. Along the western border of the plateau tens of thousands of oaks were felled, the trunks and larger limbs stripped for tan bark, the wood left to rot or to make fuel to feed the fires. These practices have not yet ceased altogether; and the poor owners of these mountain lands are growing poorer every year. One who will look from the windows of the cars on the Cincinnati Southern railway, all the way from the crossing of the Cumberland river to Chattanooga, may see as far as the eye can reach east and west, the broken tops and terminal branches of the trees scorched and sickened by the ruinous fires, so that growth has ceased and they are slowly dying. The native grasses are disappearing, and the whole country is putting on the appearance of senile decay. So far, few attempts have been made to introduce grasses to replace those destroyed by the mistaken practices of half a century, and very little effort has been made to stop the destruction of what remains of the once abundant forest, nor does there seem to be a thought of systematic reforestation.

There are hundreds of thousands of these acres as good as the type of which we present analyses, and other tens of thousands of acres much better. Upon such soils we cannot expect to grow wheat, corn, or any of the cereals, profitably. Fifty years hence, when the demands of a larger population may offer nearby markets for all the products of the garden and the truck farm, for the growing of which on small areas there can be liberal use of manures, there will be in this territory thousands of homes where plenty and peace may bless their owners all seasons of the year—provided we take thought, and without further delay resolutely set about the work of salvation and restoration.

First of all, we must convince all concerned that the annual firings of the forest are not only sure to bring disaster in the future, but that they are the worst possible method of treatment of the free pasturage of these woodland summer ranges. One-tenth of the time and labor expended every year in fighting fires or following lost cattle upon their long travels in search of scanty pasturage, will seed a wide area to grasses and perennial or selfseeding forage plants, upon which three to five times as many cattle and sheep can live and grow fat; but it is useless to attempt any measure of improvement or even to stay the gradual ruin of the whole territory, until forest fires are in some way absolutely prevented.

If the farmers of these last years of the nineteenth century can spare a little time from the absorbing study of ways and means and "how to make buckle and tongue meet," to think of what may be the future of their grandchildren in the year 1950, they will begin without delay a new industry—one that will pay as large profits, and more surely than any other—the planting and rearing of forest and timber trees. People who live as if to-day is the only day to be thought of, and that their own short lives are the only lives worth living and providing for, will never undertake such work; but the thoughtful man who is a good citizen in the best sense will understand the imminent necessity, and will not only begin, but will follow up the work of reforestation as long as spared to labor and to plan. Upon the Cumberland plateau the writer has noted hundreds of localities where the seeding and care of a plantation of pines, just such as grow vigorously upon these soils, will in a very few years multiply by fifty or a hundred the present value of the land. And the same thing can be said as to many other trees which flourish upon the mountain top. Along the western margin, black walnut, white oak, chestnut oak, mulberry, red cedar, and the short-leaved pine (*pinus mitis*) can be made to grow, while upon the plateau proper, post oak, black oak, chestnut oak, the pines, and in many places the pignut and mockernut hickory, will grow lustily where decently cared for. There ought to be thousands of acres of the short-leaved yellow pine where there are now a few clump-like groups rarely covering more than a few acres.

It will be observed, upon inspection of the chemical analyses of the mountain soil, that the soluble silica, potash and alumina "show up" well, and that lime and phosphoric acid are deficient. The physical analysis shows a large proportional content of "clay," while the body of the soil is made up of coarse silt and the medium grades of sand. In the working of these soils it is found that the potash, which appears to be nearly as abundant in the subsoil as in the upper soil, is in some way either leached away beyond the reach of the cultivated plants, or is locked up in insoluble compounds and so not available. It is found, also, that the deficiency of phosphoric acid as shown by analysis is evidenced by results in the very first crop grown upon the soil.

This sandy soil weighs 94 pounds per cubic foot; an acre ten inches deep weighs 3,400,000 pounds. We have in the upper ten inches of the soil 527 pounds of phosphoric acid. Under the best conditions, upon good land, we have found that of the total phosphoric acid contained in the upper cultivated stratum, about one-sixth is in proximately available form. In this particular soil, therefore, we may assume that not more than 88 pounds per acre of phosphoric acid can be drawn upon to supply the demands of a crop, even if the soil is in the finest condition of tilth, and the roots should be able to reach out in every direction and appropriate it. Under exceptionally good conditions, with seasonable and abundant rainfall, as much as ten bushels per acre of fairly good wheat have been harvested from lands like this the first year after clearing; but that was the last.

In its natural condition the "clay" constituent of this soil is fairly well mixed with the entire mass, all the way to within one or two inches of the surface, which is usually almost pure sand with a very small mixture of decaying vegetable matter—a sort of imperfect humus. When these lands have been plowed, as they commonly are, with bull-tongue or shovel plow, which simply stirs but does not invert and so re-mix the soil, the clay goes quickly downward. Because of the comparative coarsness of the sand silt, no hard pan is formed at small depth until after many years of cultivation; this is partly due, also, to the prevailing method of plowing and the implements used. For all that, it has been found that in many places—and this is perhaps more generally the case than has been usually observed—this fine clay finds a halting place at no great depth, and does clog and impede the movement of the soil waters. Upon lands of this kind several years under cultivation, the writer has seen water standing for a day or two in post holes only 30 inches deep. It is not hard to understand why fruit trees set upon these lands which have been cropped for a number of years, do not make healthy and vigorous growth. Upon this plateau are grown apples as good as the best; peaches, plums and cherries, the first named too often caught by the late spring frosts; grapes abundantly; and some tobacco; but no careful farmer will plant either of these except upon new land.

The use of coarse manures, with occasional application of lime;

when commercial fertilizers are employed, those carrying the phosphoric acid largely in the water-soluble state, and the nitrogen preferably from cotton-seed meal or other slowly soluble materials; the growing of leguminous plants, as cow-peas, &c., to be turned under; and in every way to add to the amount of humus material, are all advisable. Moreover, it is well, when the arable soil has become well supplied with humus material, that the bull tongue plow give place to an implement which will mix and re-mix the materials, and so gradually build up a loamy and fertile soil.

NO. 6. SAINT LOUIS (CORAL) LIMESTONE—Soil 0—6 inches; sub-soil 6—12 inches.

LOCALITY—Woodland, 200 yards S. E. from railway station, Maxwell, Franklin county.

UNDERLYING ROCK—Cherty, fossiliferous limestone (Coral Bed of Safford); which overlies the silicious lower carboniferous rocks of No. 8 of this series.

FOREST GROWTH—Post oak, red oak, black oak, hickories, persimmon, sassafras; new growth includes red cedar.

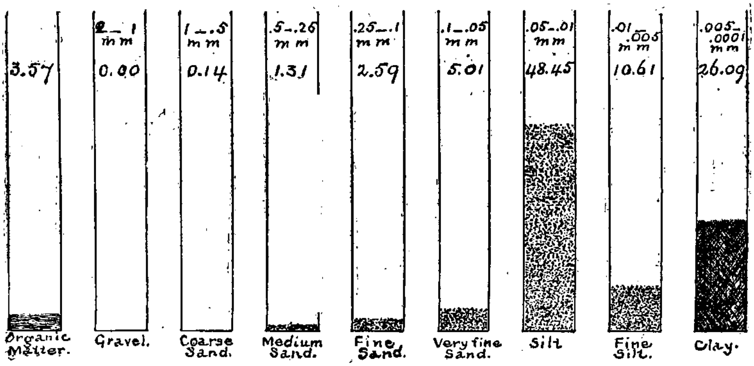
USUAL CROPS ON SIMILAR SOILS—Wheat, oats, corn, the meadow grasses, fruits and vegetables.

ANALYSES OF SOIL AND SUBSOIL, No. 6.—Coral Limestone.

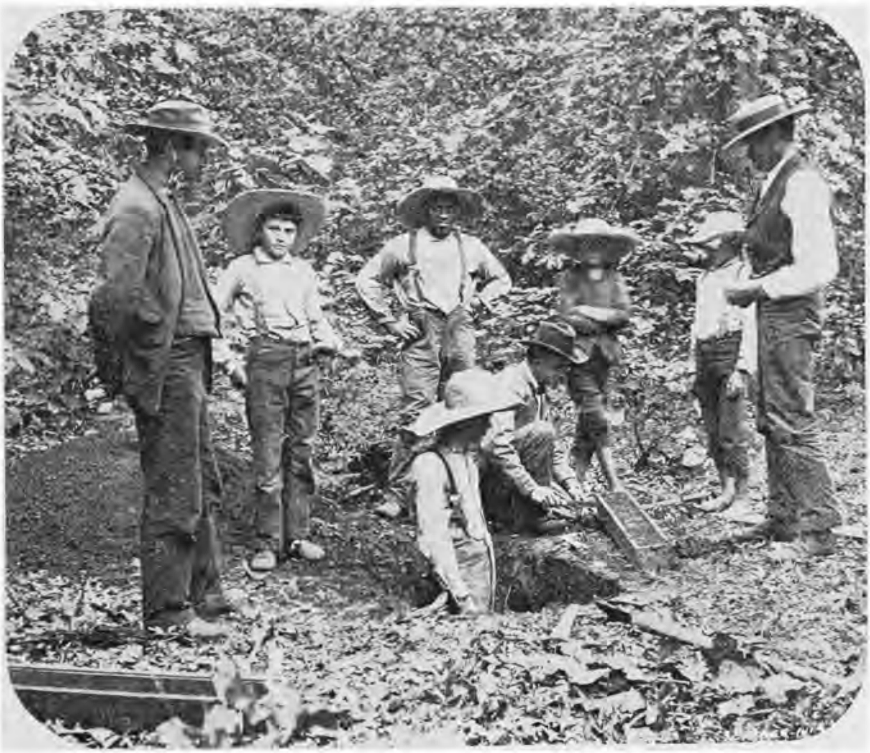
		Soil		Subsoil
Insoluble Residue	75.520		75.765	
Residue soluble in Na_2CO_3	6.958	82,478	7.270	83.035
Potash, K_2O		0.340		0.320
Soda, Na_2O		0.132		0.107
Lime, CaO		0.100		0.106
Magnesia, MgO		0.265		0.234
Ferric Oxide, Fe_2O_3		2.928		3.116
Alumina, Al_2O_3		6.475		7.413
Phosphoric Acid, P_2O_5		0.022		0.021
Sulphuric Acid, SO_3		0.010		0.008
Volatile matter		4.900		3.216
Moisture		1.960		1.760
Humus in Soil	1.536			

Original sample contained—	In soil	In subsoil
Coarse gravel, 25–2 mm diameter	0.77	0.85
Fine gravel, 2–1 mm diameter	0.64	0.36
Fine earth, less than 1 mm diameter	98.59	98.79

TEXTURE OF THE "RED LAND" (CORAL LIMESTONE) SOIL; FRANKLIN COUNTY, TENN.—6–718.



For more than thirty years prior to the civil war the culture of cotton was almost the sole employment of the negroes, who were vastly the larger number of farm laborers in this section of country. The lands suffered badly because of the methods of cultivation then in vogue. Shallow plowing was the rule in those days, and manures were suffered to waste. The best of the farms were begining to show that fertility was decreasing, and the inevitable results of continuous cropping in cotton on such lands had



NEAR MAXWELL, FRANKLIN COUNTY.

already started the washes, which later grew in number and in depth and threatened to reduce the fields to barren wastes. The vicious system of share farming, during the years when the "bottom rail was on top," and the once industrious and obedient slave was a full partner in the crop and cared nothing for the land, worked as little as he pleased and only when and how he pleased, was bringing this beautiful country rapidly to ruin. The almost incredible changes, wrought by the better methods of the last fifteen years, have excited the admiration of all who remember the gloomy prospects in 1870.

These red lands are clay loams, originally very productive, washing readily where neglected, but easily kept in place by careful management. They differ slightly from the lands of the same geological horizon in Robertson, Montgomery and other counties of the tobacco region, in containing rather more of iron and alumina, less of lime, and are somewhat of coarser texture. The better lands of this type are nearer the mountain slopes, and this is true all the way from Franklin county to Pickett. Everywhere in this strip of territory the red lands are naturally fertile. Southwestward from the headwaters of Elk river there are lands of this kind upon which cotton can be grown as profitably now as ever; where this crop is made to take its place in a well-planned rotation, and is not allowed to usurp exclusive care and attention, there is no reason why it may not be cultivated as one of the sure money-makers. All the way from the Alabama line and northward to Kentucky these red lands produce wheat of superior quality, with good yields per acre wherever the deficiency of phosphoric acid is supplied by timely use of superphosphates. Nowhere in the State are lands that more certainly respond to the intelligent use of fertilizers. The experiences of farmers have been such as to justify still more liberal applications, especially where the system of farming has been such as to keep the soil in best physical condition and to maintain the abundant supply of humus material. Upon old and somewhat worn lands of this type moderate applications of lime have proven of great value; and there are a few instances of marked improvement where dressings of 1,000 to 2,000 pounds of limestone or marble dust per acre were the only amendments used. Experiences all over this red land country confirm the indications of the analyses, and show in most conclusive manner that chemical tests of representative soils have a real practical value. The use of high grade superphosphates, whether upon lands comparatively new or upon such as are already somewhat impoverished, has almost without exception proved to be a paying investment. The farmers of this region have learned that commercial manures are indispensable, and that they pay best on good land; that the best are the cheapest, and that low grade fertilizers are never worth the prices asked for them. They have also learned that stable and yard manures have for their lands a value much greater than because of the nitrogen, phosphoric acid and potash content alone, and that when used in combination with commercial fertilizers the results are largely better than when either the one or the other class of manures is used alone. To-day in hundreds of fields one can see how easy it is for the ignorant and careless to waste these lands, and how easy it is for the wise and provident to keep them and to make them more and more productive.

These soils, and those of closely similar origin and characteristics overlying the sub-carboniferous or mountain limestone and the coral (*lithostrotion*, etc.) limestone, are without question the best in the State for all classes of fruits. The areas are marked 8 in the accompanying map.

No. 8. The "Barrens" of the Highlands—Soil 0—5 inches; Subsoil 5—10 inches.

Locality—Woodland of J. G. Aydelott, ½ mile east of Tullahoma, Coffee County.

Underlying Rock—The Silicious group, the lower carboniferous of the St. Louis.

Forest Growth—"Barren oaks"—scrub or black-jack, etc.; huckleberries, etc.

Usual Crops Upon Similar Soils—Small crops of oats, wheat, corn, etc.

Except along the streams and in certain basin-like depressions, the lands of this section (of which there are large areas represented by the type sample), are but little cultivated, though moderately productive when newly cleared. If drained and fertilized these soils may be made valuable.

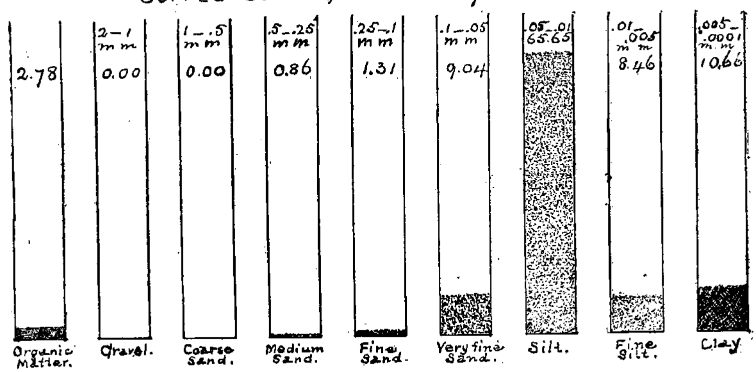
ANALYSES OF SOIL AND SUBSOIL NO. 8.—"The Barrens."

		Soil		Subsoil
Insoluble Residue	86.895		86.160	
Residue soluble in Na_2CO_3	3.660	90.555	4.538	90.698
Potash, K_2O		0.218		0.240
Soda, Na_2O		0.074		0.065
Lime, CaO		0.100		0.057
Magnesia, MgO		0.090		0.126
Ferric Oxide, Fe_2O_3		1.775		1.889
Alumina, Al_2O_3		2.540		3.604
Phosphoric Acid, P_2O_5		0.010		0.007
Sulphuric Acid, SO_3		trace		trace
Volatile matter		3.203		2.226
Moisture		0.980		0.853

Humus 1.068

Original sample contained—	in soil	in subsoil
Coarse Gravel 20—2 mm diameter	2.48	2.63
Fine gravel 2—1 mm diameter	0.80	0.72
Fine earth less than 1 mm diameter	96.72	96.65

TEXTURE OF THE "BARRENS" (SILICIOUS SUB-CARBONIFEROUS) SOIL, COFFEE COUNTY, TENN.—8-722.



The "barrens" embrace extensive tracts in that part of the highland rim next below the red lands already described. These tracts are generally level, with a sparse growth of trees rarely of great size, and have a soil for the most part thin, greatly deficient in calcareous matter. The picture shows the characteristic growth on this type of soils, the bit of forest land represented not having given a tree to the axe in the memory of the oldest inhabitant.

Upon this class of lands it is not advisable to use the sub-soil plow. Thorough underdrainage is the best possible way to begin such improvement as will make them certainly profitable. Deep plowing, as the term is understood for this region,—six inches, rarely eight inches,—when preparing lands for wheat, is always advisable, provided this work can be done in midsummer, and then only when the land is in good condition, sufficiently moist, but not wet. When about to begin the work the farmer on the

NEAR TULLAHOMA, COFFEE COUNTY.

"barrens" should be careful to ascertain that the good condition referred to exists to the full depth for which he sets his plow. For this purpose it is well to dig into the earth in several places in the field. The surface to a depth of two to four inches will sometimes be dry enough, while at the depth of six or seven inches the earth will be found over-wet. Fall plowing, as a preparation for spring crops, as corn, oats, tobacco, etc., is advisable only when a good coat of vegetable matter is to be turned under. Clean lands, such as tobacco lands and corn fields which have been kept free of weeds by thorough cultivation, should be left alone till in proper condition in the early spring; or, better still, should be seeded to rye, winter oats, crimson clover, or some suitable cover-growth—this work to be done early enough to get a fair growth before the winter rains set in. An excellent plan is to seed the corn field to rye, sowing among the standing corn any time in August, when there is opportunity. It will pay to do this even if it is necessary to turn down an immense growth of such catch-crop, to prepare the soil for the spring plantings previously determined upon. The operations of plowing, etc., at any season of the year should not be preceded by burning over the land, as is too frequently done. When it is necessary to clear away sprouts or brush, one should be very careful that the brush-pile fires are not allowed to spread; no vegetable matter which can be incorporated into the soil, and so furnish humus material, should be wasted.

At a depth of 20 to 24 inches, an almost impervious clay,—properly speaking it is a mixture of unctuous clay with an exceedingly fine silt,—is found underlying the soils to which the not inappropriate name of "barrens" is given. This under-stratum is found at or about this depth over the whole territory of this geological horizon. On the western side of this highland rim, soils of the same character are rather more fertile naturally, because the under-clay is not quite so near the surface.

Near the escarpment of the highland rim, where outlets for underdrains or for surface ditches can be reached without too great expense, it is comparatively easy to make the "barrens" abundantly productive. There are numerous outlets for the soil waters into the small streams, and in many places to sink-holes which reach through the underlying rocks into the under-ground streams. Such sink-holes should be kept open wherever they exist.

Some of the best fields of this region are those which have been reclaimed by well-planned surface drainage. These are areas of slight depression below the level of the surrounding country, sometimes a square mile or so in extent, upon which the waters collect to a depth of only a few inches, and remain for several weeks in spring and fall until lost by evaporation.

As we get further away from the edge of the highland rim the flat barrens are less easily handled, and there is greater need of neighborly kindness among adjoining owners, so that the problem of drainage may not be made impossible of solution because of denial of outlet for surface waters. The paucity and dwarfish growth of the trees is not altogether due to the poverty of the soil proper, but mainly to its small depth overlying an impervious under-soil, which holds the water line too near the surface during the wet season of the year, and shuts off the deeper stores of moisture in the dry seasons.

By the growing of leguminous plants to be turned under; by the application of moderate dressings of lime *after* the construction of well-planned surface drains; by the saving and use of stable and farmyard manures, these distributed upon the land as fast as produced; by combining with all these the use of commercial fertilizers in liberal doses, a few thoughtful and observant men have proven that these long-neglected lands are capable of producing remunerative crops.

In many sections of the territory (marked 7 on the map), can be found considerable areas admirably suited to the growing of tobacco. Where the under drainage is good, or where it can be secured at reasonable cost, grapes and the various small fruits can be successfully grown, and, with the help of fertilizers, there is little doubt that the growing of beets of high sugar content can be made successful. Wherever transportation can be had by good common roads to near-by consuming or shipping markets, truck farming in all its branches can be made profitable.

NO. 9. BLUE LIMESTONE OF THE NASHVILLE FORMATION.—Hudson River Group. Soil 0—7 inches; subsoil 7—14 inches.

LOCALITY.—450 yards north of Maj. Campbell Brown's residence, near Spring Hill, Maury County.

UNDERLYING ROCK—Blue limestone, slightly cherty.

FOREST GROWTH—Beech, elms, ash, oaks, hickory, hackberry, walnut, etc.

USUAL CROPS UPON SIMILAR SOILS—All the cereals and grasses; the type of the bluegrass region of Tennessee.

Land from which the type sample was taken has been in grass fifty years or more. Timber has been gradually removed; the land has never been cultivated; is grazing ground now and has been used as such since "opened." Similar lands under cultivation throughout the Central Basin of Middle Tennessee have been cropped almost every year for more than a half century, in some instances seventy-five years, and, where not suffered to wash, are still productive.

IN MAURY COUNTY—MIDSUMMER.

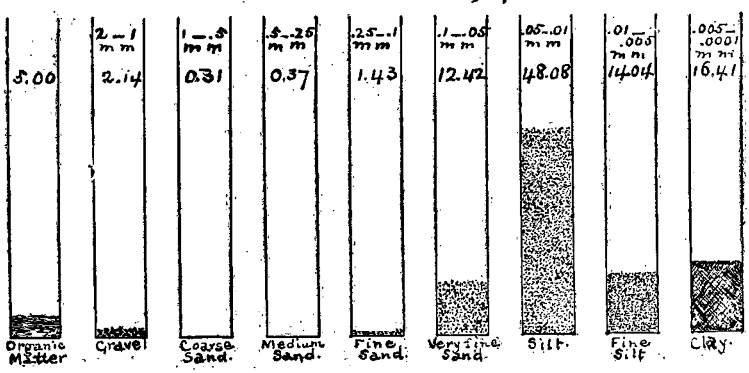
This picture gives an excellent view of a portion of the magnificent farm, the home of the late Campbell Brown. In the middle distance is the low hill upon the western slope of which the soil sample was secured. The photograph was taken on the 18th of July. There had been good rains all through the spring and summer, and the pastures and paddocks were everywhere covered with luxuriant vegetation. Not alone upon this well-kept domain, but everywhere throughout this section, the midsummer had brought promise of abundant crops of grasses and grains, promise which was later fulfilled so that all the land rejoiced. In midsummer of the following year there was "just enough to get along with" on this farm, while the people of the country round about were sorely pressed to find green pastures for their cattle, and taking the stock to water demanded hours of service every day. This was one of the summer droughts which come rarely in this part of the State, and are all the more discomforting because of their rarity.

ANALYSES OF SOIL AND SUBSOIL NO. 9.—Blue Limestone.

		Soil		Subsoil
Insoluble Residue	76.045		79.612	
Residue soluble in Na_2CO_3	6.390	82.435	5.920	85.532
Potash, K_2O		0.410		0.435
Soda, Na_2O		0.172		0.182
Lime, CaO		0.510		0.398
Magnesia, MgO		0.290		0.328
Ferric Oxide, Fe_2O_3		2.096		2.284
Alumina, Al_2O_3		4.281		4.228
Phosphoric Acid, P_2O_5		0.158		0.142
Sulphuric Acid, SO_3		0.031		0.025
Volatile matter		6.966		4.216
Moisture		2.476		1.666
Humus	2.919			

Original sample contained—	Soil	Subsoil
Coarse gravel, 32 to 2 mm diameter	14.70	9.82
Fine gravel, 2 to 1 mm diameter	3.27	2.80
Fine earth less than 1 mm diameter	82.03	87.38

TEXTURE OF BLUE GRASS (NASHVILLE LIMESTONE) SOIL, MAURY COUNTY, TENN.—9-724.



With the exception of the "bottom lands"—riparian alluvials of small area,—and here and there instances of soil building by the washing of earth and debris from badly managed fields on the neighboring slopes, the soils of the Central Basin are almost wholly *soils in place*, derived from the underlying rocks. There are characteristics which mark differences between varieties of the soils. The red clay lands of Rutherford, Bedford, Marshall, the brown lands of Sumner, Trousdale, Lincoln, aud Giles, the so-called poplar lands of Maury, Williamson, and Wilson, and the mulatto lands of Davidson, Williamson, and Moore counties, have marked peculiarities; nevertheless there is such likeness among them that the type selected is closely comparable with each and all.

There are thousands of fields in the Central Basin of Middle Tennessee, under cultivation almost continuously for fifty or sixty years and still fairly productive, upon which not a wagon load of manure has been used. To this day, upon the greater number of farms not a single ton of commercial fertilizers has been purchased.

The analyses of the type sample from the hillside near Spring Hill, representing, as it does, several hundred thousands of acres equally as good throughout Middle Tennessee, show why the fortunate possessors of these lands have not yet been induced to attempt systematic fertilization. The few who have undertaken (in an experimental way) the application of chemical manures, have in most cases failed to realize their somewhat unreasonable expectations of immediate results, and have persuaded themselves that such manures do not pay. The faith of the average farmer in this Garden of the State is in the main well-founded. Barring prolonged droughts, he is sure to make enough to enable him to get along, and he is always looking ahead for a good season when his labor will be rewarded with an abundance so great as to over-tax his barns and fill his pocket-book besides. The good seasons and the bountiful crops come often enough to keep alive his belief in the unimpaired fertility of his soils.

In the surface soil of four-fifths of the virgin lands of this limestone country, there was a supply of mineral food elements for crops of thirty bushels of wheat per acre annually for two hundred years before exhausting the phosphoric acid in the upper twelve inches. In a field cleared eighty years before, the writer found wheat roots reaching into the soil to a depth of more than three feet, and this in so many places in the field as to indicate that the average depth from which the roots were obtaining food was certainly more than two feet. The season was favorable, but the yield of this field was only 14 bushels per acre. The average yield of wheat that year (1879), for the counties of Middle Tennessee, was eight and a half bushels; for the whole State the same year the average yield, according to the census returns, was eight bushels. A few yields were reported in 1879 as high as 30 to 40 bushels, but these were remarkable exceptions then, and

NEAR SPRING HILL, MAURY COUNTY.

are rare enough now to be talked of as marvelous. Indian corn is the chief product of Middle Tennessee: for that same year, 1879, the average yield of the State was 21.6 bushels per acre, and that of the limestone counties of the Basin 25.5 bushels. There were this year a few extraordinary crops of 80 to 100 bushels of corn per acre. Now, if the crop of 1879 had been singular in results, unusually below the average yield of corn, cotton, and wheat, several conditions might serve to explain such meagre returns from a soil so rich; but the records, so far as we have them, show that the average yields for 1879 were, of corn about 5 bushels, of wheat nearly a bushel, and of cotton 60 pounds of lint per acre more than the average of 20 years, 1869 to 1889.

The original fertility of the lands under consideration is admitted by all who know the country. The analyses confirm the claim, and show why the lands are rich. Nevertheless, the crops, for the past twenty-five years at least, in the most favorable seasons, have not been such as these soils ought to produce. With the exception of cotton, of which more hereafter, the history of crop returns for the twenty years 1869 to 1889 does not materially differ from that of the twenty years 1859 to 1879; and *in this fact there is hope for the future.* That so great variety of agricultural products have been grown for nearly one hundred years upon these lands, for the most part without the help of manures, and by methods which have varied little during three generations of farmers, is proof of the fertility and durability of the soils, and gives promise of results under better methods such as will fulfill the brightest expectations. That the average yields per acre have been only moderately good for all by-gone years is evidence that the old ways were accepted as good ways, and that the great body of farmers have contented themselves to let well-enough alone; but when we know that a very considerable number of land owners in Middle Tennessee have improved upon the old ways, and have greatly increased the productiveness of their lands, there is proof that much the greater number are contenting themselves with decreasing yields, for in no other way can the continued low average be accounted for.

It is not worth while to recall the past history of this magnificent domain. What the virgin soils were is shown by the analyses given on preceding pages. What the soils are now, ought to be carefully studied, each man for himself and for his own land. The upper arable soil, to an average depth of fifteen inches, was loaded with humus, varying from 2½ to 3 per cent of the weight of the mass of earth to that depth. Rich in potash and phosphoric acid, with abundant supply of lime; the clay constituent varying from 15 to 30 per cent, rarely falling as low as

18 per cent; with from 60 to 70 per cent of silt; all these, in newly cleared lands, intimately mixed to a depth of many feet; the physical condition of the original soils was such as resisted for two score years all that the active labor of man could do to disarrange the constituents of the soil stratum, and to make vigorous plant growth doubtful where once it was as certain as the return of the seasons.

In the "good old times," there were dry seasons, when the mill wheels on the smaller streams ceased to turn, when the water grew shallow in the wells, the corn blades twisted in cork-screw fashion, the warm-blooded cotton plants, tired of the prolonged heat and faint with thirst, dropped half their burden of unripe fruit, and farmers had long faces because of short crops. There were doubtless dry years long before the white man came with his ax and his plow, when wild beasts fought for water at little pools that were a few weeks before broad and deep enough to drown the biggest of them. And there will come in the future other times when the grasses wither, the springs fail, and fish die in stagnant ponds in the stream-ways. These are calamities which have come, and may come again, to this as to all other lands.

During the period from 1865 to 1897 inclusive, we have had only two years of wide spread and long continued drought,—in 1874, when the corn crop of that year was nearly all consumed before the first snow of December; and in 1897, the effects of which are yet to be measured. Since 1871 there have been eleven May droughts so-called, four of such intensity and duration as to dwarf the growth of plants, and in a great many places make it necessary to plant the corn fields a second time. These May droughts are much feared by the cotton planter in Middle Tennessee. Of July droughts there have been twelve, only three of which were of such character as to seriously injure fields which had been thoroughly cultivated. From the testimony of the oldest citizens of the Middle Tennessee counties, and from numerous written and printed documents running back to 1835, we conclude that short "dry spells," as well as the longer ones deserving the name of droughts, are no more frequent since 1871 than during the thirty-six years preceding; but the common testimony is that the ill effects of these dry seasons seem to be more hurtful as the years go by.

Climatological Data, March 1, 1871, to June 1, 1897.

NASHVILLE, TENNESSEE.

	Av. mean temperature deg. Fah.	Av. rainfall inches		Av. mean temperature deg. Fah.	Av. rainfall inches.
March	48.7	5.36			
April	59.7	4.72			
May	68.1	3.43	Spring	58.8	13.51
June	76.2	4.20			
July	79.3	4.38			
August	77.5	3.33	Summer	77.7	11.91
September	70.7	4.00			
October	59.5	2.41			
November	48.0	3.91	Fall	59.4	10.32
December	41.7	3.57			
January	38.0	5.07			
February	42.4	5.20	Winter	40.7	13.84

Average annual rainfall, 26 years, 49.53 inches.

The table here given is from the records of the Weather Service. A comparison of figures with those from the volunteer observers at four other stations in the Central Basin, shows minor local variances, but a general agreement essentially with those of the Nashville station. The climatic conditions with which we have to deal are practically alike for the whole of this valley. These conditions we must accept as entirely beyond our control; by no contrivance can we turn aside the winds or govern the flight of the clouds. But with the soil we can do what we will. We can waste it, certainly. We can starve it into barrenness. We can neglect it until it becomes foul with weeds and wild growth that harbor fungous and insect enemies to poison and destroy. And we can keep it, feed it, care for it, until every rood of the worn lands of our farms shall yield as much as any acre of our choice fields.

There are few level areas of any extent in this section of the State. On the steep slopes of East Tennessee it is not any more difficult to prevent surface washing than in this slightly rolling country. Indeed, more skill, as well as good judgment, is demanded here than in the mountainous region or in the more level West Tennessee counties. This is one of the first things to be done whenever the farmer will set about permanent improvement of his lands. In the "laying off" for planting, in the direction of the longer furrows when breaking the land, and where space will allow, a modified system of terraces or of surface drains, must be so directed as to catch the surface waters and deliver them at the foot of the slope by a gentle descent of not more than one foot to five hundred—one inch to 40 feet of drain. There must be careful consideration in advance, and equally careful execution of plans adopted. It is best that all of the rain shall percolate into the land upon which it falls, and that it shall not flow off upon the surface. This is rarely possible in the open fields, even under the best conditions; but there should be endeavor in this direction, not only for the conservation of plant food, but to lessen the injury to the physical condition of the soil which always comes from the rapid movement of overflow waters. Wherever upon the nearly level lands of this region (except, of course, the small areas of alluvials subject to overflow), the rain waters submerge the fields and remain standing for hours, or for days, as the writer has seen in the red clay sections, at the first opportunity the under soil should be deepened. The use of the subsoil plow in midsummer or early fall is here indicated, as the next best thing to thorough under-drainage.

In the cotton growing districts of Rutherford, Giles, Maury, and Lincoln, there are lands which have been for several decades planted in cotton two or three years out of five, until the yield is so small and the quality of lint so poor that this crop has been abandoned wholly or in part by the greater number of farmers. The best lands were for many years, before and after the civil war, devoted specially to cotton. To use plain language, the cotton fields have suffered such brutal methods of tillage as could have had no other result than exhaustion. Happily, those who are to come after us will find, as many of the more progressive farmers have already found, that only the upper four to six inches of the surface of the soil have been impoverished, and that there is another farm underneath the one now apparently worn to barrenness, with stores of mineral plant food waiting to feed abounding crops for those who will set about undoing past wrongs and earnestly study how to do the right things in the right ways.

What has been said on pages 64 and 65 about the clay lands of East Tennessee is applicable with respect to all the soils of the Great Basin. In the main, the lands of central Middle Tennessee are better than those of the East Tennessee valley. That they are not more productive is because of the too common neglect of most of the plainly necessary precautions just referred to, and because of the failure to save and apply every pound of farm manures, and to use in connection therewith, in liberal measure, such concentrated fertilizers as are now available for every farmer in the State. No sane man who is honest will advise this or that special brand of commercial fertilizers, to be applied to several fields or for several crops on the same farm. The only way to know what is best is to make experiments, which each man can vary to suit his own needs and conditions. That the farmers of the deservedly famous Garden of the State must use fertilizers is certain. The sooner they realize that manures of all sorts pay best upon good land the better. Fertilizers will not take the place of tillage, but will rather demand better tillage. The better the physical condition of the soil the more likely will the use of farm manures, chemical fertilizers, or fertilizer materials, bring profitable results.

With the rapid increase of territory devoted to the service of King Cotton under conditions of soil and climate more suited to its production, there is no special inducement to increase the acreage in either of the Middle Tennessee counties in which it was once a staple crop. There are better things for the farmer of this section. But, for all that, there is no good reason why cotton should not be made a profitable crop, taking its place in a well-considered rotation. If only the lint is sold, and the seed, or its equivalent in plant food constituents, is returned to the soil which grew the crop, cotton is the least exhaustive of the agricultural products of this section. The prevailing methods, however, must be changed. If this cannot be done so that the resources of the soil—not for six inches of the surface, but for ten times that depth—can be made to answer the demands of other or succeeding crops, then it should be without hesitation abandoned once for all.

No. 10. St. Louis (Coral) Limestone.—Soil 0—6 inches; subsoil 6—12 inches.

Locality—Woodland, 500 yards S. E. from railway depot at Adams' Station, Robertson County.

Underlying Rock—The lithostrotion bed of the St. Louis limestone, somewhat silicious.

Forest Growth—White, black, and red oaks; poplar (tulip tree), hickory, black walnut, dogwood, persimmon, etc.

Usual Crops Upon Similar Soils—Corn, tobacco, wheat, etc. Well-known tobacco lands; very productive for many years;

NEAR ADAMS STATION, ROBERTSON COUNTY.

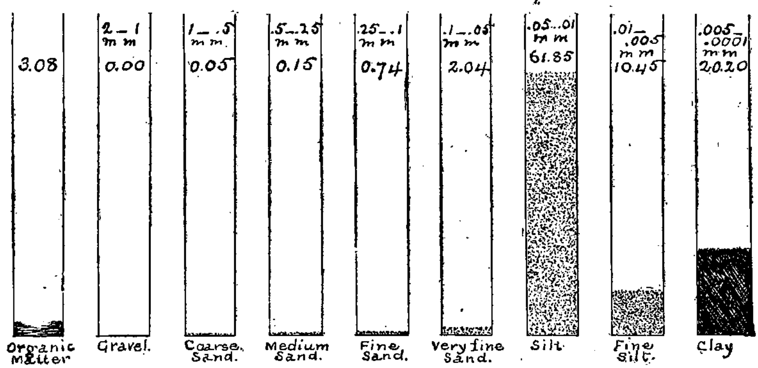
durable under good management. Not so "red" as the lands of No. 6 of this series; do not wash quite so easily, simply because more nearly level. Though of finer texture than the "red lands" already described, the lands of the "Clarksville tobacco district," when long under cultivation, appear less able to resist drought than the more clayey, but coarser grained soils of No. 6.

ANALYSES OF SOIL AND SUBSOIL, No. 10.—Coral Limestone.

		Soil		Subsoil
Insoluble Residue	78.359		78.868	
Residue soluble in Na_2CO_3	6.671	85,030	7.526	88.394
Potash, K_2O		0.393		0.431
Soda, Na_2O		0.169		0.230
Lime, CaO		0.278		0.139
Magnesia, MgO		0.355		0.290
Ferric Oxide, Fe_2O_3		2.134		2.304
Alumina, Al_2O_3		4.388		5.574
Phosphoric Acid, P_2O_5		0.078		0.047
Sulphuric Acid, SO_3		0.023		0.024
Volatile matter		4.400		2.766
Moisture		1.753		1.400
Humus in Soil	1.652			

Original sample contained—	Soil	Subsoil
Coarse gravel, 20–2 mm diameter	0.33	0.07
Fine gravel, 2–1 mm diameter	0.51	0.36
Fine earth, less than 1 mm diameter	99.16	99.57

TEXTURE OF "CLARKSVILLE" TOBACCO (CORAL LIMESTONE) SOIL, ROBERTSON COUNTY, TENN.—10–726.



The striking family likeness between this type of soils and the red lands of Franklin County, as will appear upon comparing both the chemical and physical analyses of the representative samples, is further proof of the practical value of such investigations. These soils are of the same parentage though from such widely separated localities. They belong to the same geological horizon, and have only such slight differences as may be accounted for by the differing conditions of uplift of the rock strata and the subsequent processes of disintegration and denudation. If the red lands of Franklin County, and along the western border of the

Cumberland plateau, were as nearly level as those of the Clarksville region, the likeness between the two would be closer still. As it is, the methods best suited to soils of the type No. 6 are doubtless equally good for those of the tobacco district. In fact, the later practices of the best farmers in the latter section differ from those of the "red land" country mainly in the kinds of so-called money crops,—tobacco and wheat in the one, and cotton and wheat in the other. The advantage to the tobacco farmers in the *ante bellum* days, if there was any, was in the smaller acreage of the tobacco fields, and therefore the less rapid destruction of timber for the annual increase of "clearings."

Among the first in Middle Tennessee to use commercial fertilizers were the growers of shipping tobacco in Montgomery and Robertson counties. The use of bone meal and superphosphates, begun twenty or twenty-five years ago by a few progressive farmers, is gradually extending. Good systems of rotation, in which the true grasses, as well as leguminous plants, have their proper places, have been adopted by many of the people, and there is promise for this region quite as remarkable changes for the better as have been brought about by the better methods upon the lands of Franklin County.

There are many areas so badly worn that systematic reforestation is the only recourse. There are no lands in the State upon which the growing of forest trees can be made more surely profitable; not in the hap-hazard way reforestation is permitted in the coaling-grounds of the iron furnaces, but with due preparation, and thoughtful planning for results to be reached after twenty or more years of faithful waiting.

The physical characteristics of the soils, which make them easy of cultivation, quick and generous in response to the plow and the hoe, are just such as have, in multitudes of places, caused them to suffer by erosions, marking the fields with fluted depressions and ridges, suggesting a likeness to flat corrugated iron roofs, quite as red and almost as bare of vegetation. Worse than this surface nakedness, is the poverty of the under soil of these worn fields, from which have been leached the lime and the soluble nitrates, potash and phosphoric acid, until even persimmon and sassafras "sprouts" seem to hesitate in growth as if ashamed to be seen in such places. But down in the lower soil we find still an abundant supply of mineral elements, beyond the reach of the plants of annual crops, but where the deep-rooted oaks, walnuts, hickories, chestnuts, and tulip trees can find food for vigorous growth, if properly planted and decently cared for.

These lands are admirably adapted to all the orchard fruits of the climate. There need be no failures in any line of fruit-tree plantings, when proper choice of aspect and exposure is made to suit the peculiar needs of chosen varieties, and when the trees are given place upon lands specially cleared for their occupancy, or upon soils not already so reduced as to approach barrenness. Trees starved in infancy can never be brought to vigorous and fruitful maturity. The picture is a view across country in

ACROSS COUNTRY IN ROBERTSON COUNTY.

Robertson County. Not more than one-third of the open lands in sight from the point of observation were under cultivation when this photograph was made, because regarded as not productive enough to pay for cropping. There are many thousands of acres of such lands in Robertson, Montgomery, Cheatham, and other counties in the areas marked 8 on the accompanying map,, only waiting the right sort of management to be made "as good as new." The reader is referred to what has been said of former and present conditions of the similar class of soils, of which the lands of Franklin County are the type.

No. 11. SANDY CRETACEOUS.—Soil 0–6; subsoil 6—12 inches.

LOCALITY—Woodland, property of Thos. H. Kelley, 1½ miles west of Camden, Benton County.

UNDERLYING ROCK—Unconsolidated strata; gray or yellow sandy soil and under soils of varying depth; silicious clays below; under strata sands, rarely found hardened into stone, 50 to 70 feet in depth.

FOREST GROWTH—White and black oak; chestnut, persimmon, sassafras, hickories, dogwood, etc. Typical undergrowth, huckleberry (*Gaylussacia resinosa*), and others of the heath family.

USUAL CROPS UPON SIMILAR SOILS—Corn, tobacco, peanuts, fruits and vegetables. This is a representative of the Ripley group of the Cretaceous of Safford; sandy cretaceous soils, with thin clay layers; here and there a slight bed of shaly clay.

WEST OF CAMDEN, BENTON COUNTY.

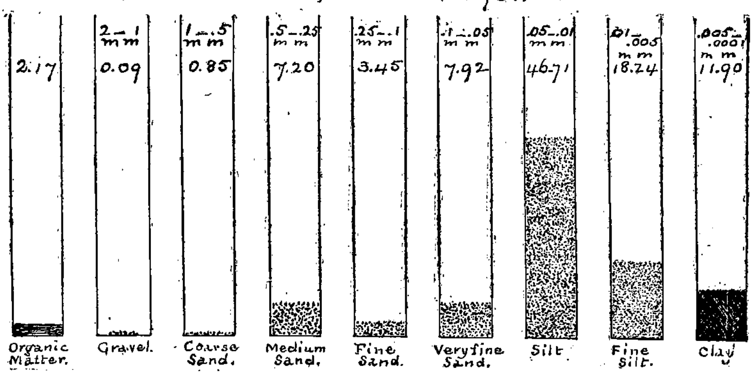
ANALYSES OF SOIL AND SUBSOIL NO. 11.—Sandy Cretaceous.

		Soil		Subsoil
Insoluble Residue	88.776		84.875	
Residue soluble in Na_2CO_3	3.482	92.258	4.956	89.831
Potash, K_2O		0.285		0.379
Soda, Na_2O		0.101		0.111
Lime, CaO		0.093		0.097
Magnesia, MgO		0.157		0.267
Ferric Oxide, Fe_2O_3		1.265		1.889
Alumina, Al_2O_3		2.640		4.181
Phosphoric Acid, P_2O_5		0.020		0.020
Sulphuric Acid, SO_3		trace		trace
Volatile matter		2.386		1.850
Moisture		0.690		1.026

Humus 0.739

Original sample contained—	Soil	Subsoil
Gravel 4—2 mm diameter	0.02	0.00
Fine gravel 2—1 mm diameter	0.34	0.30
Fine earth less than 1 mm diameter	99.64	99.70

TEXTURE OF "SANDY CRETACEOUS" (Safford) SOIL, BENTON COUNTY, TENN.—11-731.



The view of the little town of Camden, the county seat of Benton County, is from the edge of the westward slope which extends to the Mississippi River.

The town stands upon the western extreme of the formation which gives distinctive character to the soils of the Clarksville region (No. 10 of this series). West of the Tennessee River these soils are found upon the higher areas of what is known as Tennessee Ridge. This ridge has but a narrow summit in Henry County, widening and more elevated southward through Benton, Decatur, Henderson and McNairy counties. Upon the more level areas of this ridge are lands equally as good as those of the same class

CAMDEN, BENTON COUNTY.

in Middle Tennessee, and there are many hundreds of localities upon the slopes, and upon the divides between the numerous streams that flow eastward and westward from the summit of the ridge, admirably adapted to the various fruits of this climate. With the Tennessee River on the east, and railway lines not far away on the western side, there is nothing wanting but good country roads to make this ridge country an ideal home for the growers of orchard and small fruits, and for garden products as well.

Next to the Tennessee Ridge lies the strip of lands represented by the type sample No. 11. The "lay of the land" is well illustrated by the view of the broad grass-grown field immediately west of the town. Not all of the lands lie as smoothly as this pictured field, for the country is diversified by level valleys and plains amid gently sloping hills and minor ridges of little height, but giving just such relief as to make beautiful the variety of landscape. This is true of all the country of the Slope, all the way to the Mississippi Bluffs. The soils of the sandy cretaceous area yield generous crops of corn, cotton and tobacco for a few years, when the returns cease to be remunerative unless the lands are kept in good heart by manuring and the regular introduction of grasses or leguminous plants to maintain the supply of humus. As is indicated by the analyses, the supply of lime and phosphoric acid is scanty. It is for this reason that wheat culture has not been successful on this class of soils. The quick disappearance of the lime under the usual system of cropping explains the frequent failures of attempts to enrich the depleted soils by growing clover, cow peas, etc., to be turned under.

In places, the undersoil at a depth of 20 to 24 inches is a reddish silicious clay for a thickness of 12 to 30 inches, in turn itself underlaid by a gray, or yellow, and occasionally orange colored mixture of about five per cent of calcareous clay with the sand. This reddish stratum is usually indicative of a soil rather stronger and more durable than where this characteristic does not exist. The natural under-drainage is good,—almost too good, where the prevailing methods of shallow culture are continued for some years. The supply of limestone at no great distance from this belt of soils, all the way from Kentucky almost to the Mississippi line, makes it comparatively easy for the people to get an agricultural lime at moderate cost. The so-called "marl beds" (green sand containing more or less of glauconite), may be used with advantage where conveniently near the fields of the more southern part of the territory; but even there, and certainly in Henry, Benton, and Decatur counties, the direct application of lime will be less costly, and probably give good results where carefully and intelligently used. It is usually a wise thing to experiment with dressings of lime, applying from 30 to 50 bushels of slacked lime per acre upon the fresh furrows made when turning down a crop of cow peas, or clover, or the stalks of corn, the sorghums, or a growth of weeds. Subsequently, the systematic use of commercial fertilizers, always following, but never preceding, a fair addition of humus material by turning down a soiling crop, or in combination with as much stable or farm yard manure as can be obtained, will doubtless be profitable.

There is need for most careful management to prevent the beginning of washes, which, once started, grow larger and wider very quickly. To "turn out" a field to *rest* is, in most cases, to turn it out for good and all. This is, in a measure, true of all the lands of the plateau slope of West Tennessee, but it is specially true of the higher-level lands of the whole region.

NO. 12. FLATWOODS: (PORTER'S CREEK GROUP of Safford);—PARIS CLAY.—Soil 0—6 inches; subsoil 6—12 inches.

LOCALITY—Woodland, property of Capt. W. H. H. H. Easton, 1½ miles N. E. from Huntingdon court house, Carroll County.

UNDERLYING ROCK—No consolidated strata. Under-soil contains slaty clays; yellow sands beneath; at depth of 50 to 70 feet, argillaceous sandy rock, in many places found at 20 to 25 feet below surface.

FOREST GROWTH—Hickories; white, black, and post oaks; persimmon, poplar (*liriodendron*), sassafras, etc. On the lower slopes near creeks a luxuriant undergrowth.

USUAL CROPS UPON SIMILAR SOILS—Corn, cotton, fruits, vegetables. All crops of the climate do well on new or well-kept old lands.

The town of Huntington is just upon the western edge of the formation to which Dr. Safford has given the designation of Flatwoods. This class of soils does not occupy a continuous territory, but is found in detached areas, in a belt not more than five miles wide in Henry County and about eight miles in width at the Mississippi line. The marked characteristic of these areas is the occurrence of heavy layers of laminated clays, containing mica scales, forming a soil and subsoil sufficiently retentive of water and fairly resistant to the effects of drought when well managed; but corn, cotton, and the other crops upon the older lands, which have been cultivated in the usual manner for a number of years, are more or less easily affected by a dry season of moderate duration.

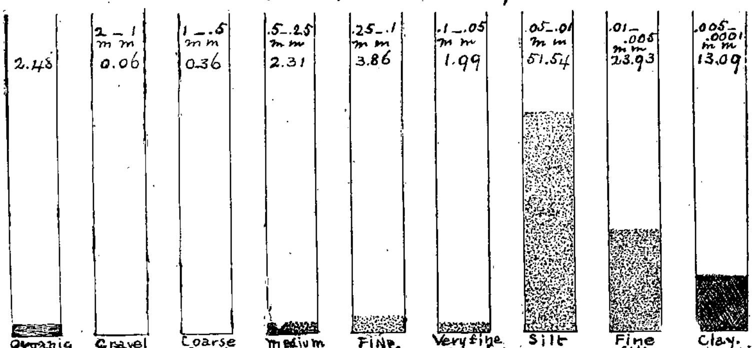
ANALYSES OF SOIL AND SUBSOIL NO. 12.—The "Flatwoods" Clay.

		Soil		Subsoil
Insoluble Residue	86.560		83.438	
Residue soluble in Na_2CO_3	3.895	90.455	5,846	89.284
Potash, K_2O		0.378		0.435
Soda, Na_2O		0.090		0.100
Lime, CaO		0.132		0.100
Magnesia, MgO		0.184		0.216
Ferric Oxide, Fe_2O_3		1.492		2.078
Alumina, Al_2O_3		2.972		4.455
Phosphoric Acid, P_2O_5		0.026		0.017
Sulphuric Acid, SO_3		0.011		0.010
Volatile Matter		3.216		2.066
Moisture		0.876		1.106

Humus 0.905

Original sample contained—	In soil	In subsoil
Coarse gravel larger than 2 mm diam	0.05	0.00
Fine gravel 2—1 mm diameter	0.16	0.15
Fine earth less than 1 mm diameter	99.79	99.85

TEXTURE OF THE FLATWOODS (PORTER'S CREEK, Safford), SOIL, CARROLL COUNTY, TENN.—12-733.



The locality from which the type sample of these Flatwoods Clay lands was taken is closely representative of the areas of like soils in this peculiar belt. The woodland selected is just such as is found on similar lands from Kentucky to Mississippi. Here, as in thousands of other places all through this region there is evidence of the magnificence of the forest growth of earlier days, and of the need for more thoughtful and conservative management of the timbered lands. The tree, the top of which is shown in the left background of the picture, had been cut down for firewood, the trunk the only part of the tree hauled to the town, the remainder left to decay where it fell. Within a radius of a hundred yards there were a number of such "laps," silent but eloquent reminders of the unheeding wastefulness too common a trait of the American people. The scarred trunks and broken tops of the greater number of the small trees showed how careless had been the work of the axmen. Twenty of fifty years

NEAR HUMBOLDT, GIBSON COUNTY.

hence, if this piece of woodland remains as such, there will be few trees with clean growth and straight bodies to represent their ancestors of better days, while most of those that remain will be fit only for firewood.

A study of the analyses will suggest several points that need to be considered by the owners of this class of lands.

The content of "clay" is comparatively small. The proportion of coarse silt is more than one-half of the entire mass of "subsoil." At a depth of twenty inches the proportion of "clay" is materially larger, and in most instances, especially upon lands under cultivation for a number of years, is quite compact. In places, where the underlying sands approach the surface more nearly, the under clays of the "Flatwoods" are intimately mixed with the coarser sands; and in such places if washes cut down two or three feet there must be prompt attention to prevent a further cutting all the way to the impervious slaty clays below.

The abundant and vigorous forest growth, always evidence of fertility in the virgin soil, cannot be taken as indicative of durability of such soils when devoted to agricultural purposes. There is no need for argument here. The people who own these, and other lands in the fertile regions of West Tennessee, cannot fail to understand that spendthrift methods will ultimately bring poverty all the more bitter because of the one-time abundance of their heritage. It is impossible to maintain the fertility of the best limestone lands without manures; the time always comes when the farmer must feed his lands or starve himself. Upon the silt soils of West Tennessee it is far more difficult to prevent the gradual but certain depletion of the essential elements of plant food. Despite the richness of the virgin soils, the continuous demands upon them for the crops, and the greater losses of plant food by percolation of water-soluble elements into the deeper sand strata, are constantly reducing the available supply in the arable stratum.

The people of the Flatwoods lands should look well to the saving and use of all farm manures, and begin at an early day the use of superphosphates, together with a systematic rotation of crops, so managed that the supply of humus material shall not be diminished, meanwhile keeping in mind that most plants will send their roots into the deeper under-soil the more readily because of the better condition of the surface stratum. There ought not to be a single acre of waste land where this type of soil exists.

All the way from the Tennessee Ridge to a line which may be said to be approximately that of the Illinois Central Railway, the essential characteristics of the soils differ from those just described only because of the general absence of the laminated clays which mark the peculiarity of the "Flatwoods" area. They demand the same methods of treatment, varying only because of special conditions.

Of the lands marked 11 on the map, we present three type samples. Though closely related, the three types have certain distinctive characteristics which we shall endeavor to describe, for each in its own place.

No. 13. COLUMBIA DEPOSITS. (LAGRANGE SANDS OVERLAID BY ORANGE SANDS. Safford.) Soil 0—6 inches; subsoil 6—12 inches.

LOCALITY—Woodland, property of Duffy Bros., ¾ mile N. E. from railway depot at Humboldt, Gibson county.

UNDERLYING ROCK—In the Humboldt area the sands are found at a depth of 12 to 16 feet. There are no underlying strata of hard rocks in the immediate vicinity. The texture of the upper twelve inches differs little from that of the Fayette County lands (No. 14), but is more loamy, containing a larger proportion of humus than the same class of lands further south. Local beds of coarse reddish sandstone are frequent throughout the region represented by this sample; these approach the surface more nearly as we go further south. Almost everywhere in the area represented by this sample, the loamy soil and subsoil, which together vary in depth from six to twenty inches, is underlaid by a clay usually yellowish, sometimes quite brown, twenty to forty inches in depth, and beneath this, strata of sands of varying depth. Below the underlying sands last mentioned are often found beds of very hard clay, usually yellow or reddish, in places grayish white and very tenacious; this is true of a large part of the territory represented by the samples Nos. 13 and 14.

FOREST GROWTH—Hickories; white, red, post and black oaks; poplar, persimmon, sassafras, beech; wild grape vines; except upon the slight ridges, a luxuriant undergrowth.

USUAL CROPS UPON SIMILAR SOILS—Corn, wheat, cotton, tobacco; fruits and market vegetables.

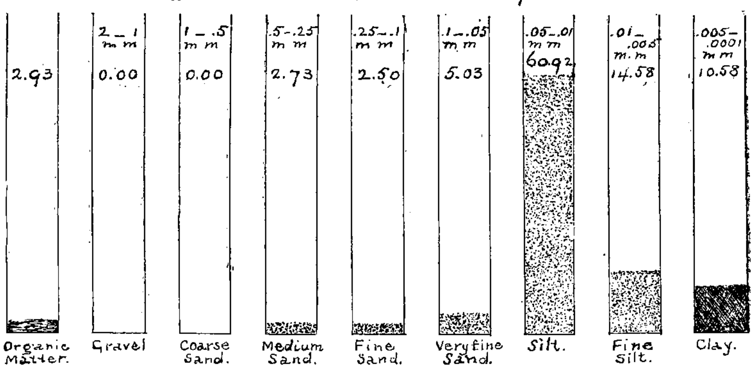
Analyses of Soil and Subsoil No. 13.

	Soil		Subsoil	
Insoluble Residue	81.154		78.675	
Residue soluble in $Na_2 CO_3$	5.514	86.668	7.357	86.032
Potash, K_2O		0.409		0.444
Soda, Na_2O		0.133		0.240
Lime, CaO		0.212		0.126
Magnesia, MgO		0.270		0.395
Ferric Oxide, F_2O_3		1.850		2.587
Alumina, Al_2O_3		4.771		5.604
Phosphoric Acid, P_2O_5		0.069		0.054
Sulphuric Acid, SO_3		0.020		0.021
Volatile matter		4.033		2.383
Moisture		1.553		1.733

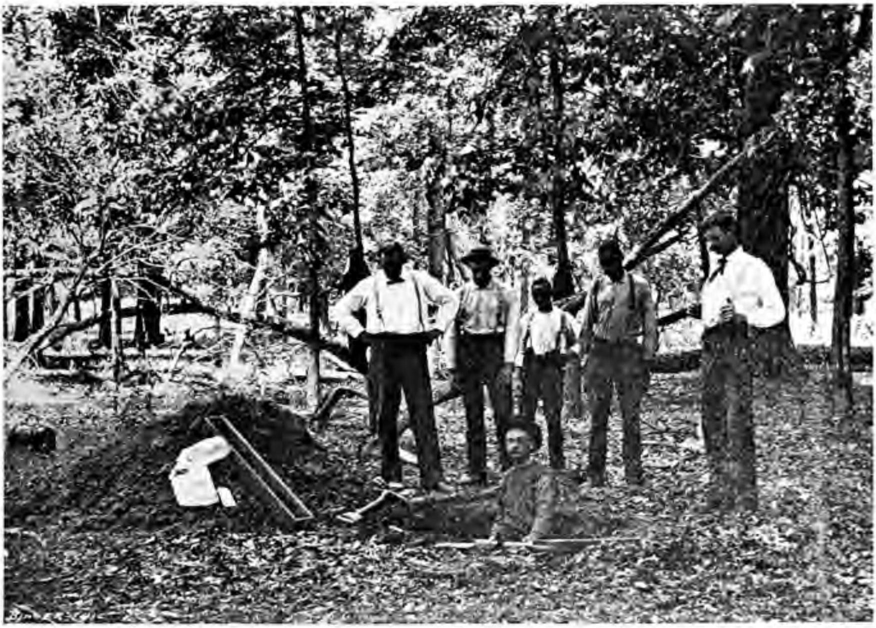
Humus 1.508

Original sample contained—	in Soil	in Subsoil
Coarse gravel, larger than 2mm diameter	0.02	0.00
Fine gravel, 2 to 1 mm diameter	0.34	0.10
Fine earth less than 1 mm diameter	99.64	99.90

Texture of the Lafayette Sands (Orange Sands, Safford); Soil, Gibson County, Tenn.—13–735.



The territory the soils of which are represented by this sample, includes the eastern half of Obion, the western half of Gibson, all of Crockett, the western half of Madison, and that part of Haywood County north of Brownsville. In wide range of adaptability for all crops of the farm, the garden, and the orchard, the lands lying between the south and north forks of Forked Deer river are not surpassed by any equal area in the State. The lands are mellow sandy loams, easily tilled, of such physical characteristics as demand careful handling if their fertility is not to be quickly wasted. Almost the entire area of this region is fit to be made into a vast garden, so freely do the soils respond to every well-directed effort; but to keep the lands the farmer must adopt the methods of the gardener rather than those of the planter. It is the ideal home of the ideal husbandman. He who is careless, indifferent, slovenly in his methods will sooner or later sell out, if he can find anybody to buy, and "go west" or to Texas.



EAST OF HUNTINGDON IN CARROLL COUNTY.

The owner of such lands as these must be something more than a mere tiller of the soil. Every acre, every square yard, of the farm, more especially the cleared fields, whether in cultivation or not, must be jealously watched. This is business for the master, not for the employee. The very fineness of the soil material, which is its prime physical characteristic, is in itself a warning against a single day of neglect. It is comparatively easy to maintain the productive capacity of the fields wherever the upper soil is kept in place; it is impossible, where surface waters are permitted to accumulate and then find outlet in streams however small.

Let it be observed that these are not clay lands. Because of the manner of their origin the content of "clay" is somewhat less here than further south in the same belt of deposits. (See No. 14). There is here, as is the case also with the land further south, a larger amount of clay in the subsoil than in the surface soil, and as we go down the "clay" constituent increases. In many places the deeper lying under-clays are so compact that it is easy to dig cisterns that will hold water almost without the help of the thin skin of cement which is usually found sufficient. Wherever this dense clay under-stratum approaches the surface,—and there are many places where it is concealed by only a foot or two of earth,—there is special need for care. In such places the soil remains longer too wet to plow, and suffers soonest and most severely from drought.

Because much that is to be said as to the soil represented by the analyses of No. 13 applies to those of the southern counties of this tier, we give in this place:

No. 14. Columbia Deposits—Lagrange Sands overlaid by Orange Sands. Safford). Soil 0—6 inches; subsoil 6—12 inches.

Locality—Woodland, property of Dr. T. B. Tansey, 2 miles N. E. from court house at Somerville, Fayette County.

Underlying Rock—Same as No. 13 of this series. Depth of soil overlying the sands not so great as in Gibson county. In the vicinity of the streams there is an occasional outcrop of ferruginous argillaceous sandstone.

Forest Growth—Post oak, willow oak, black oak, some scrub oaks, hickories, sassafras, honey-locust, etc.

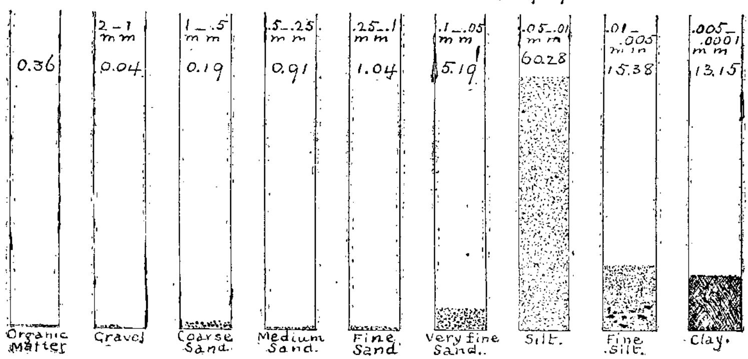
Usual Crops on Similar Soils—Corn and cotton mainly. New lands productive for a long period where well kept. Upon the slopes, however slight, they wash rapidly.

ANALYSES OF SOIL AND SUBSOIL, No. 14.—Typical Cotton Lands.

		Soil		Subsoil
Insoluble Residue	84.054		79.800	
Residue soluble in Na_2CO_3	4.380	88,434	6.733	86.533
Potash, K_2O		0.380		0.494
Soda, Na_2O		0.085		0.301
Lime, CaO		0.205		0.152
Magnesia, MgO		0.246		0.351
Ferric Oxide, Fe_2O_3		1.889		2.814
Alumina, Al_2O_3		3.400		4.972
Phosphoric Acid, P_2O_5		0.071		0.074
Sulphuric Acid, SO_3		0.018		0.012
Volatile matter		3.600		2.557
Moisture		1.307		1.500
Humus	1.356			

Original sample contained—	in Soil	in Subsoil
Coarse gravel, larger than 2 mm diam.	0.04	0.00
Fine gravel, 2–1 mm diameter	0.14	0.08
Fine earth, less than 1 mm diameter	99.82	99.92

TEXTURE OF THE LAFAYETTE SANDS (ORANGE SANDS, Safford), SOIL, FAYETTE COUNTY, TENN.—14-737.



An inspection of the analyses of the two soils (Nos. 13 and 14) shows them to be very closely alike in chemical composition and in texture. There are areas in the territory of one that are in every way counterparts of areas in the other; but the samples were taken from localities which represent, as accurately as possible, the great body of land in each, and indicate clearly the differences between the two sections of this belt of country. The lands of No. 13 are, as has been said (page 104), underlaid at varying depths by clayey strata, in places very fine and compact. Wherever these beds of clay approach the surface there is need for surface drains or ditches to carry away the surplus rain water, or for systems of underdrainage which shall relieve the arable soil and at the same time increase the capacity of the under-soil to hold stores of water available, by reason of the improved capillarity, when needed by the growing plants. The same physical conditions exist in the lands of No. 14, with more uniformity. The compact, impervious under-clays are almost

IN FAYETTE COUNTY—NEAR SOMERVILLE.

everywhere present at a depth of 20 to 35 inches, the soil and subsoil above generally sandy with so little of clay that a moderate rain disappears as quickly as it falls.

Only in the bottoms and "second bottoms" of Wolf, Loosahatchie, and other streams, are the virgin lands well supplied with humus. Upon the slightly undulating area reaching northward into Haywood county, as well as in the hilly lands with broad intervening plateaus of the more westerly part of this section, the soil seems to lose the greater part of its original supply of organic matter, and thereafter its lime constituent, very rapidly.

Because of its peculiar adaptation to the growth of cotton this has been the leading crop of this section for more than fifty years. Now and then, even before the "troubles of the sixties," there were protests against the tyranny of cotton, and we heard much of the ruin which was threatened to the lands of Fayette and Haywood, and elsewhere in West Tennessee. As has been said of the stronger lands of Middle Tennessee, the injury that has come to the soils is not because of the cotton plant, nor altogether because of faulty methods of cultivation. The earlier farmers and planters of southwestern Tennessee, were not long in finding out how difficult it is to retain these soils; but for reasons then thought sufficient, they went on clearing up new lands to furnish employment for the rapidly increasing numbers of slave laborers. Among those pioneer farmers were many highly educated men from the Carolinas and Virginia, whose experiences in the older States had taught them valuable lessons. Somewhere about 1850, under the leadership of such men as H. J. Cannon, Charles Dod, Jr., Rice Bond, and others, the people began the work of conservation and restoration, and set themselves to study out and practice the best methods "to prevent their lands from running away." There was during the ten years up to 1860, great progress in the betterment of the open lands and more careful management of the wooded areas. Then came the civil war, which was followed by a long period of readjustment, years of weary struggle for existence, which left neither labor nor money for improvement, and forced upon the people systems and methods ruinous alike to landowner, renter, "share hand," and hired man. Such were the conditions from 1864 to 1880. These sixteen years have left upon the face of the country such scars as that here illustrated.

All through this region there are hundreds of just such washes, and thousands more not so deep nor so wide. In every instance the beginning was almost unnoticed. Nine-tenths of these "gullies" had their birth in the cultivated fields, and might have been checked if timely attention had been given them. We can adopt, word for word, what Dr. W. J. McGhee says of the same character of lands further south: "These gullies are growing with ever increasing rapidity; already they have grown beyond the abandoned fields in which they started, and are invading the woodlands." In the back ground of the picture can be seen how steadily this typical gully is reaching into the beautiful little town close by.

HOW A "GULLY" GROWS.

The neglects which permitted the beginnings of these gullies were just such as helped to deplete the soils, until the fields were no longer fit for cultivation and caused them to be abandoned to certain ruin.

The cotton field shown in the picture is, like many others in this section, so slightly undulating as to appear almost level. The crop on this field was only "tolerable,"—about 600 pounds of seed cotton per acre. When first planted to cotton the yield averaged 1,200 pounds of seed cotton—385 pounds of lint per acre. When the writer saw it this field appeared to have been well kept. Because of a very slight fall westward, the rows had been "laid out" so as to be as nearly level as possible. Cultivation had been such as to leave the interspaces between the rows quite flat ; altogether there was evidence of unusually good management.

The absence of stumps of trees showed that the land had been cleared twenty years or more. Probably twelve or fifteen crops of cotton had been grown upon this field, and five to eight crops of corn. So far as could be learned, no manures had been

A COTTON FIELD IN FAYETTE COUNTY.

applied. For all that, this land was already much less productive than it ought to have been. The body of the soil had not "started to the Gulf," because there was here a fairly good imitation of the system which was adopted in the management of the Melton place by Col. H. J. Cannon in the *ante bellum* days,—the absolutely level rows. Over and above the slow depletion of plant food elements by the removal of the successive crops, there was unquestionable loss of fertility. The average yield of cotton had fallen from 1,200 pounds to 600 pounds per acre. No information as to the average crops of corn could be obtained by the writer in his very short interview with an apparently well-informed gentleman during the limited delay of the railway train.

Nothing is more clearly demonstrable than that the mineral elements (the ash constituents), of such crops as are carried away must be restored to the soil in some way, if ultimate sterility is not to result. These soils (Nos. 13 and 14), in their virgin state contained, in the 12 inches of upper soil, (assuming a cubic foot of the soil to weigh 95 pounds*), of potash 0.41 %, 17,860 lbs.; of phosphoric acid, 0.064 %, 2,787 lbs.; of lime 0.165 %, 7,187 lbs. Comparing this statement of average supply of mineral plant food with the average requirement of a crop of 1,500 lbs. per acre of seed cotton, (potash 15.48 lbs., phosphoric acid 13.36 lbs., and lime 2.65 lbs.), there seems to be sufficient of the least abundant of these elements for 200 crops of cotton yielding 1,500 lbs. seed cotton per acre! But there are several other things to be considered. To mature this crop of 1,500 lbs. of seed cotton, food must be available for the whole plant. The whole plant for the supposed crop will consist of 472 lbs. of lint, 1,028 lbs of seed, 636 lbs. of bolls (capsules), 906 lbs. of leaves, 1,030 lbs. of stems, and 393 lbs. of roots. The average analyses of parts of the air-dried cotton plant (as given page 125 Bulletin IV., 5, Tenn. Exp. Sta., 1891), calculated for such a crop, show:

		Lbs. Phos. Acid	Lbs. Potash	Lbs. Lime	Lbs. Nitrogen
In the Lint,	472 lbs.	2.88	3.49	0.73	1.13
" Seed,	1028 "	10.48	11.99	1.92	31.56
" Bolls,	636 "	1.79	19 21	5.91	7.08
" Leaves.	906 "	4.05	10.36	49.75	21.83
" Stems,	1030 "	1.92	12.11	8.74	8.08
" Roots,	393 "	0.60	4.32	2.13	2.55
Total,	4465 "	21.72	61.48	69.18	73.23

In earlier days, when nothing was sold away from the farm but the lint, the net loss of mineral plant food was very small, provided the seed were returned to the soil which produced them. As a matter of fact, only such seed as were used for planting were returned to the land. Until the development of the cotton oil business, little was known of the value of cotton seed as a feed

*A number of weighings by the writer gave an average of 94.3 pounds.

stuff for cattle, and its manurial value was very imperfectly understood, so that millions of dollars' worth of animal and plant food were wasted every year.

If conditions are such in any particular field that all of the bolls, leaves, stems, as well as the roots of the plant, can be returned to the soil where the plants grew, that is well. If neither waters nor winds sweep away the debris of the dead plants, the cotton grower upon level lands may sleep soundly, if he contents himself with the notion that the only losses his fields are suffering can be measured by the plant food elements sold off in the lint and seed of his crop; but nowhere on earth do the conditions exist that can justify the keeping of such an account of debit and credit with the soil. There are other items of the account, the precise character and amount of which are not easy to determine.

We may reasonably assume for Tennessee the estimate by Hugh Robert Mill for Great Britain, that of the annual rainfall "one-third is returned to the air by evaporation, one-third flows off over the surface, and one-third sinks into the ground." These grand distributions of the rainwaters may not, as a whole, be materially affected, but the least careful observer can note the immediate effects of the changed conditions brought about by human interference. In the forest, on the prairie, on well-kept meadows and pasture land, there is rarely such surface flow as to work serious injury; on cultivated fields the gentlest rainfall brings about some movement of earth particles, some change of place of the mass of the upper stratum, some alterations of the texture of the soil. As has already been said, endeavor should be made to reduce the surface movement of the waters, and as far as possible, to promote the percolation of the rain into the land upon which it falls. Now, upon the silt soils of West Tennessee it is specially necessary so to arrange the disposition of the crops and methods of cultivation, that the fields shall not be gashed and furrowed by flowing waters, that quick absorption of the rains into the upper soil be invited, and that the undersoil be so managed that ready percolation of the surface waters shall not be impeded. All these things can be done; but there are others.

The most retentive of soils, such as contain from 25 to 30 per cent. of "clay," give up to the drainage waters more or less of the plant food elements which have been made soluble by the aid of the multiple processes of cultivation. These silt soils may be rapidly impoverished by filtration, and this none the less rapidly when most carefully guarded against losses by surface washing.

Of the total phosphoric acid and potash in soils a very small per centage is found in soluble condition, and of this small proportion a part is retained, however excessive the downward movement of percolating waters. For these elements of plant food we may be content to restore them annually, or at sufficiently short intervals, so that there may not be less than the original content, in an "available" form. A rough estimation of the amounts per acre removed by the crops will enable us to determine how much of these two elements are to be restored, and which must be restored if fertility is to be maintained. But in whetever form applied, the condition of these two elements of plant food depends upon the presence, in sufficient quantities and also in the right condition, of what is roughly stated in the analyses as organic (volatile) matter, and of lime, etc. Referring to the statement above (page 110), the crop of 1,500 pounds of seed cotton and the plants to produce it, demand 21.72 pounds of phosphoric acid, 61.48 pounds of potash, 69.18 pounds of lime, 72.23 pounds of nitrogen. If we suppose that all parts of the plant, except the seed cotton, are returned to the soil without loss, this vegetable matter will be in time converted into its original elements, and so be used again as food for succeding plants, except so much as may be carried off by the drainage waters.

For the soils of this section we have no data from which to make an approximate estimate of the losses of plant food due to drainage alone. The fact that the productive capacity of level land, where there has been little or no surface washing, is gradually but certainly reduced by continuous or alternating crops of corn and cotton, is matter of common observation. The best kept lands show this. Upon the stronger soils of the limestone sections of the State, decreased fertility of fields not manured is due much more to continuous leachings than to the removal of successive crops. In this same way the rich sandy loams of West Tennessee are impoverished, only with greater rapidity. In the corn and cotton fields of the silt lands of this region there is going on, during the fall, winter and early spring, a period of about five months, an almost unceasing drainage into the deeper underlying sands, carrying the soluble nitrates, largely of the lime, as well as portions of the soluble potash and phosphoric acid. Where there are no applications of fertilizers, to the net loss of plant food elements removed by the crops, there must be added such losses as occur because of the removal by washing away of the debris of the plants left upon or in the upper two or three inches of the soil, and a further loss by drainage,—the amount of the loss by drainage depending upon the absorbent properties of the soil as well as its physical condition. Under the best conditions, and the prevailing methods of culture in the cotton fields, the losses of nitrogen by drainage are from one-half to four-fifths of the amount of the same element utilized by the plants. If we assume that one-half as much of nitrogen as is required for the growth and maturation of the cotton plant is carried off by the drainage alone, and that the field is so managed that the whole of the debris of the plants is retained by the soil upon which they grow, and that only the seed cotton is removed, it appears that the annual draft upon the available nitrogen alone, by the average crop yield of 1,500 lbs. of seed cotton per acre will be 69.3 pounds. To maintain the fertility of the cotton fields it is necessary, therefore, to supply, in one form or another, such manures as will furnish at least seventy pounds of available nitrogen per acre,—this minimum for such fields as are not impoverished by surface washing. If farm manures are the only material at hand, and such as are best suited to sandy soils be used,—namely, well rotted stable manures,—there will be required an annual dressing of seven tons per acre. This return of plant food (seventy pounds of nitrogen, thirty-five pounds of phosphoric acid, and eighty-five pounds of potash), must be made, if the land is to be kept up to such productive capacity as to yield an average of one bale of cotton per acre.

The statement is made as above so that each man may determine for himself how he shall manure his land so as to maintain its fertility. To farm without manuring is to impoverish the soil and to defraud posterity. Everyone who will can estimate very closely the cost, under his own conditions, of seven tons of fairly well rotted manure, or the equivalent of about nine tons of fresh stable manure, including, of course, the cost of hauling and spreading upon the land. Whatever this cost, the amount represents the money value of what must be returned to the soil, if the original capital of fertility is to stand unimpaired.

Now, just to the extent that one can prevent the losses of plant food by waste of the organic matter in the stubble of the crop by washing and by drainage during the long exposure of the bare soil to the heavy rainfalls of the latitude, one can reduce the necessary amount of manuring. The best farmers understand this, and, in one way or another, are practicing methods to conserve the fertility of their lands. The planting of cover or catch crops, such as shall occupy the soil all fall and winter, to a very great extent preventing the leaching away of the surplus plant food made soluble by cultivation of the regular crops of the year, at the same time helping to maintain the soil in place, is coming more into use.

Here, as in other sections of the State, occasional droughts bring disaster. Whenever the upper foot of soil contains less than ten per cent. of moisture the cotton plant begins to suffer, and the more seriously because of the low growth of the plant and the large area of earth surface exposed to the sun and the winds. For best development of the plant, in stem, leaf, and lint, these loamy soils should hold about fifteen per cent. of moisture, and therefore endeavor must be made to secure that condition.

As necessary for the better understanding of the agricultural problems of this region the following table is given. The rainfall and temperature records at Memphis may be considered applicable to that part of Tennessee south of the Forked Deer River and eastward to the Tennessee Ridge. North of Forked Deer River and eastward to the highlands of Middle Tennessee, the meteorological conditions are closely represented by the observations recorded at Nashville as given on page 86.

Climatological Data, March 1, 1871, to June 1, 1897.

MEMPHIS, TENNESSEE.

	Av. mean temperature deg. Fah.	Av. rainfall inches		Av. mean temperature deg. Fah.	Av. rainfall inches.
March	51.4	5.98			
April	62.2	5.42			
May	70.3	4.33	Spring	61.3	15.73
June	77.7	4.59			
July	80.7	3.40			
August	79.0	3.50	Summer	79.1	11.49
September	72.1	3.07			
October	61.4	2.74			
November	50.1	4.81	Fall	61.2	10.62
December	43.9	3.69			
January	40.7	5.62			
February	44.6	5.22	Winter	43.1	14.53

Average annual rainfall, 26 years, 52.34 inches.

Cotton is "laid by" in August, sometimes during the third week of July. When cotton followed cotton upon the same field,—an old-time practice now avoided whenever practicable,—the surface between rows was left bare except for the small amount of debris from falling leaves, the empty bolls and broken twigs of the plants, and the dry remains of a thin growth of annual grasses or weeds which had started after the final act of cultivation. From the first killing frost, usually in October, till the plows were started to throw up the first furrows for the succeeding crop, there was nothing to prevent the percolating waters from carrying away much of the "fatness of the land" beyond possible recovery. The heavier the total rainfall from October 1st to April 1st,—the average precipitation during that period being about twenty-eight inches,—the greater the loss by drainage. When to this loss of plant food there is added the other serious losses which occur upon all fields where the cotton rows are not laid exactly level, no one can wonder at the rapid exhaustion of these soils, so justly famed for their exuberant fertility when recently cleared.

Methods must differ, because of the varying conditions upon every farm. Throughout this region, upon every square mile, there are many problems which demand for their solution the most careful thought, unceasing vigilance, and decisive action.

First of all is the prevention of surface washing. This requires something more than the skill of the plowman, and will tax the ingenuity of the well-equipped agricultural engineer. No plan can be effective for a single field, nor for any limited area, except at a cost so great as to make it impracticable. Common consent, requiring neighborly co-operation, is absolutely necessary if there is to be real success. There are many farmers in this section who remember when such streams as the Loosahatchie and Wolf flowed with good depth almost the year round, when practicable fords were not very numerous, and bridges were needed upon the upper waters of these rivers. The total annual outflow from these streams is no less now than it was fifty years ago. The yearly rainfall no longer finds its way to the Mississippi by way of perennially flowing springs and brooks, the soil slowly parting with its stores of water to feed the larger streams through thousands of sparkling rivulets; but there come disastrous freshets, when the suddenly burdened channel ways are filled to the brim with rushing floods, the waters carrying unnumbered tons of soil gathered from tens of thousands of acres. Under natural conditions the face of the country has been slowly chiseled into lines of beauty,—mountain and hill, valley and river together joined as parts of one harmonious whole; under new and artificial conditions, with little thought beyond the fancied necessities of a single day, we have cut and hewn with 'prentice hand until the beauty that was altogether useful has been changed to hideous and useless deformity.

It is not only in West Tennessee that we must mourn over wide spread ruin. From Sullivan county all the way to Shelby, upon all types of soils, in some places with fearful rapidity, in some places almost imperceptibly, but everywhere surely, we are industriously feeding the Gulf and starving our lands. One must endeavor to realize the immensity of the annual transportation seaward from the great watershed of the Mississippi valley, that the hopeless inadequacy of mere individual effort to hold the soil in place may be fully understood.

To repeat: common consent, agreement, requiring neighborly co-operation, is absolutely necessary, if there is to be real success in preventing the waste of lands by washing. There must be systematic, unfaltering effort to return to natural conditions everywhere and in every way possible. Beginnings must be made, each man for himself and upon his own land. On every farm in Tennessee there is a spring or a brook, part of a stream, perhaps only a channel for a wet-weather flow; let the beginnings for better things be made in such places. No man should suffer a gallon of water carrying mud or silt to flow from his field upon his neighbor's land, if he can prevent it. And further still, there should be endeavor that water springing from the earth or falling from the clouds within the boundary of the farm, shall carry into the near-by stream neither earth nor vegetable matter. In most cases this is not only possible, but easily accomplished in this comparatively level region of West Tennessee. How this is to be done must be determined by the conditions in each case. Once the farmer has set himself resolutely to work, seeking the most effective way by which he may conserve the God-given rainfall that is sent to bless the land, the way will not be hidden.

But in many places,—perhaps in most places,—every precaution adopted by one man, and all the results of his thoughtful labor and skill, may go for naught, if there be selfish, or careless, or ignorant neighbors. Statutes nowhere provide that every land-owner shall take care of his own share of the rainfall; the mere suggestion of such a thing will provoke derision. Floods terribly destructive, and droughts that bring famine, against which no human foresight can provide, come now and then to all countries under the sun. But the little floods that come with moderate rainfall, perhaps a score of times every year, working slow, almost imperceptible, but fatally certain destruction, can be and ought to be prevented; and the dry seasons, about which we are so anxious in spring time and summer, can be provided against in great measure. To a certain extent these things are under human control; in a small way by individuals, every man on his own farm; in a larger and more effective way by communities; and still more effectively where the people of a whole state think and work together for the common good and common safety.

By the individual: Let it be a duty,—self-imposed for self-interest, if you please, but also because it is the right thing to do for the help of his fellow men of to-day and for those who are to live after him,—let it be a duty to care for his fields that are no longer fruitful, and that they may not be abandoned to utter waste. If for any reason whatever it becomes necessary to "turn out" a field, let him see to it that it is not suffered to "start on its way to the Gulf," strive to keep the soil in place, make some effort to clothe it with vegetation, plant trees, sow seed of plants that will make roots and stems and leaves,—in some way help nature to rebuild and restore.

By the community: Let every man emulate his neighbor in the endeavor to save all the land from ruin. Not denying the right of any person to lay waste his own property, provided he does not endanger nor defraud other persons, we must insist that such person shall not be the sole judge as to whether or not the exercise of his right may work injury to others. The community is most prosperous, and always the happiest, where the right to waste is never exercised, and where there is most of that mutual helpfulness that makes the right of the person least opposed to the right of the whole people.

By the State: By wise legislation promoting reforestation; probably best by the release from taxation, for twenty years, of "abandoned lands," whether one acre or hundreds of acres the property of a citizen tax-payer, when planted to forest trees, such plantation to be maintained and protected in proper condition for the whole number of years for which the taxes are released. A well considered and carefully guarded law, applying, as it must, to every square mile of our territory, will lead our people to begin at once the rehabilitation of waste places, and so increase the value of all such lands as to give the commonwealth, within a quarter of a century, taxable real estate worth a hundred times as much as the present assessable value of these abandoned lands.

No. 15. COLUMBIAN DEPOSITS. (The LOESS, BLUFF LOAM of Safford.) Soil 0—8 inches; subsoil 8—16 inches.

LOCALITY—Woodland of Dr. F. G. Mason, one mile east from railway station at Newbern, Dyer County.

UNDERLYING ROCKS—No consolidated strata. Soil color changes perceptibly at about a depth of 8 inches; a further change at a depth of 16 inches, assumed as the limit of subsoil. Undersoil apparently as fertile as the subsoil to an unmeasured depth, a larger proportion of clay being the only indicator of difference, aside from gradual change of color. A stratum of gravel is found at depths varying from 25 to 80 feet.

FOREST GROWTH—Pig-nut, shell-bark, and white hickory; white, red, black, post, and willow oaks; elms, varieties; poplar; sweet-gum, black-gum, ash, hornbean, dogwood; a dense growth everywhere in the uncleared forests.

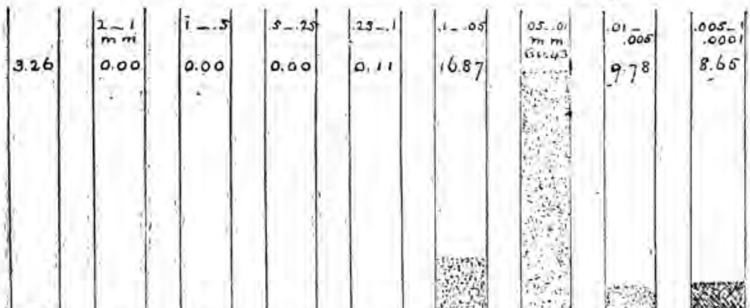
USUAL CROPS UPON SIMILAR SOILS—Corn, cotton; in the northern counties, wheat and tobacco, the meadow grasses. Excellent land, claimed to be of inexhaustible fertility.

ANALYSES OF SOIL AND SUBSOIL, No. 15.—Bluff Loam.

		Soil		Subsoil
Insoluble Residue	79.360		79.045	
Residue soluble in Na_2CO_3	6.455	85.815	7.930	86.975
Potash, K_2O		0.416		0.420
Soda, Na_2O		0.172		0.227
Lime, CaO		0.199		0.271
Magnesia, MgO		0.290		0.360
Ferric Oxide, Fe_2O_3		2.059		2.455
Alumina, Al_2O_3		3.978		4.921
Phosphoric Acid, P_2O_5		0.113		0.089
Sulphuric Acid, SO_3		0.015		0.013
Volatile matter		4.373		2.217
Moisture		1.900		1.666
Humus	1.626			

Original sample contained—	Soil	Subsoil
Coarse gravel, larger than 2 mm diam.	0.61	0.22
Fine gravel, 2-1 mm diameter	1.50	0.94
Fine earth, less than 1 mm diameter	97.89	98.84

TEXTURE OF LOESS (BLUFF LOAM) SOIL,
DYER COUNTY, TENN.—15-739.



The locality from which this type sample of soil was taken was selected because it represented the chemical composition and physical characteristics of this wonderfully fertile belt of territory, embracing the west half of Obion and all of the counties of Dyer, Lauderdale, Tipton, and Shelby, except such portions of each as lie in the River bottom.

Of the alluvial plain lands in the Mississippi bottom, probably four-fifths, somewhere near 600 square miles, lie within the counties of Obion, Dyer, and Lauderdale. A very large portion of this irregular strip is subject to overflow. The cleared and cultivated lands lie along and near the river. The low "back" lands, dotted with bayous, lakes and broad cypress swamps, are heavily forest-covered,—innumerable giants overtopping a dense growth of trees, themselves of great size, with a thick undergrowth of smaller trees and clambering vines. The ax and the saw mill have been kept busy, but in many places there are wildernesses almost untouched. No attempt was made to examine these soils. Fifty years hence, when engineering skill, with patient industry, shall have worked out an effective plan to protect this plain from overflows, or from the not impossible fate of becoming itself the center stream-way of the great river, those who are to follow us may be called to study how to maintain or to restore the fertility of these very lands. Just now we are more concerned as to the probable results of the rapid deforestation which is going on in this particular area, and especially as to the disposition of the lands from which the better timber trees are being removed with little apparent care for the fate of the growth left standing.

NEAR NEWBERN, DYER COUNTY.

The trees shown in the picture are the survivors of unnumbered forays of the lumbermen and a half century of demands for firewood. More than the usual care has been given this strip of forest land, The larger trees left standing are still in their lusty youth, and the smaller ones, selected because of desirable kinds, are encouraged to make rapid growth by systematic removal of underbrush. The absence of nutritious grasses, except a few of the annuals of little value, suggests the need for constant effort to introduce such perennial grasses as may be suited to the soils of the moderately open woodlands.

From this partially cleared woodland stretches away to the southward an almost virgin forest. On its border stood, as if sentinel defender of his smaller brethren, a great hickory, more than a hundred feet high, with a trunk fifty feet to the lowest limb, and so big around that three of the largest men of our party stood, side by side, close against the bole, without covering the diameter from view. Farther in this forest we could see the uplifted heads of scores of immense trees of many kinds. The absence of deadened terminal branches and the clean bark near the ground, showed that there had been no forest fires—possibly because, if once such fire is well started only the lakes and wide bayous can set limit to the fearful disaster that will follow, but more probably because these wooded lands are property of intelligent and vigilant owners, whose homes are almost everywhere surrounded by this "boundless contiguity of shade."

When one travels over, or digs deeply into, the virgin soil of such lands as these, one is inclined to accept as true the often-repeated claim that the lands of this region are of inexhaustible fertility. Nevertheless, the best of these soils can be, and large fields are already, practically "worn out."

For more than thirty years many of the best farmers have practiced excellent methods, preventing washes by "horizontalizing" (laying the rows of corn, cotton, and other crops so as to be very nearly or quite level from end to end); by hillside ditching to protect the slopes; and by the adoption of systems of rotation in lieu of the old-time one or two years' "rest" of fields evidently needing restorative measures.

In the counties of Obion and Dyer are found many instances of the value of good systems of underdrainage as compared with open ditches. It is beyond any doubt that thorough underdrainage can be profitably introduced into the counties of Lauderdale, Tipton, and Shelby. For all present demands, and for perhaps twenty years to come, there can be little need to "clear" more land. Taken in time, it is easier and will cost less in money and labor, to bring up the productiveness of the lands already cleared, than to open new lands and fit them for profitable cultivation.

If there is any doubt that there is needed, for a clear understanding of our soils, not only the practical experiences of the working farmer, but careful investigation of their chemical constituents and physical texture, to a depth several times more than that of the arable stratum, the reader is requested to compare the analyses of two soils, that of the "Barrens," No. 8, and that of the "bluff loam." The "Barrens" are supposed to be the poorest lands in the State except the sandy mountain plateau, while the "bluff loams" are confessed to be the richest within our borders.

If we had no other information as to these two soils than the mechanical analyses given on pages 76 and 119, we should pronounce them almost identical,—the "Barren" soil a little the better of the two. To the depth of 16 inches in the one case and 12 inches in the other, if one should consider the physical characteristics alone, the same methods of plowing, planting, and cultivation would apply to both.

When we compare the chemical analyses of the two we can begin to understand something of what is the real meaning of the mineral plant food constituents of the soil. *The average weight per cubic foot of the type soil of the "Barrens" is very nearly the same as that of the type of the "bluff loams," and can be stated at 95 pounds for each. Stating the totals per acre as indicated by the analyses, we have :

	"Barrens"	Bluff loam.
Of Potash, K_2O	9.477 lbs	12.911 lbs.
" Lime, CaO	3.269 "	7.283 "
" Phosphoric Acid, P_2O_5	372 "	3.145 "

But there are other differences. The statement on page 118 as to the depth of the soil proper, the character of the so-called sub-

*Several weighings by the writer show for the "Barrens" 95.3 pounds per cubic foot; for the bluff loam 94.6 pounds. Conditions in each case were nearly the same. On the "barren" lands the total rainfall for the six months preceding the taking of the sample for weighing had been 26.13 inches, and on the lands of Dyer county 27.08 inches. No rains had fallen for ten days previous to weighing in each case.

soil, and of the under-soil of the Dyer county lands, is true as to nine-tenths of the virgin lands of this region, not including the river "bottoms." The depth of the arable soil may be fairly stated as very nearly an average of 26 inches. Upon the "Barrens" the arable soil is rarely as much as 6 inches deep.

Upon the "barren" lands open ditches to get rid of surplus water, subsoiling under right conditions, and underdrainage wherever practicable, to improve the texture of the under-soil by lowering the surface of the ground water and so enlarging the area in which the roots of plants may live comfortably and thrive vigorously, are plainly in the line of improvement.

Upon the loess lands, to get rid of surface water is one thing accomplished by ditching and by underdrainage. A more important object is the conservation of water,—to retain this water, not in such quantity as to over-saturate the lower soil and so shut out vital processes, but so that by proper methods of cultivation it may be invited to return when needed toward the surface, where undue loss by evaporation may be checked, while a larger supply can be made available for the growing plants. Upon these silt soils of West Tennessee it is far more important than on the "barrens" that cover crops shall have a place in the corn, cotton, and tobacco fields, and that leguminous plants shall be grown as frequently as possible to maintain the supply of humus material.

The expression, "humus material," so often used in the foregoing pages, with the repeated suggestion that an adequate supply of such material is of prime importance, seems to need further discussion. On page 39 are definitions of the terms used in the several analyses of soils. Volatile matters, organic matters, are humus materials. Humus, defined as "partially decayed organic matter," does not bear any certain proportion to the amount of "volatile matter" contained in a given soil. Inspection of the chemical analyses will show that the humus in the various soils in proportion to the volatile matter found, is in some cases less than 25 per cent. (21.56 % in soil No. 7, that of the sandstone land of the Cumberland plateau), to nearly 42 per cent., (41.90% in soil No. 9). At first glance it seems difficult to understand that the soil of No. 15 (Dyer County) should contain a smaller total of organic matter, itself containing a less proportion of humus, than the soil of No. 9 (Maury County). When the description of each, as to depth of the soil proper, and as to the kind of subsoil and undersoil, the character of the forest growth, and especially the kind of grasses and herbaceous plants forming the immediate soil cover, is fully understood, the differences are at once apparent. Such lands as those of the type No 9 are properly termed durable; while those of the type No. 15, in spite of their abounding fertility, are far less durable. To either will come practical sterility under careless or bad management,—to the strong lands of Maury County a sort of impotence, like that of a healthy man starving for food and drink, who can be restored by care to his former vigor; to the silt soils of Dyer County, that sort of death-like exhaustion that must wait upon the miracles of nature for restoration.

As an abundant supply of organic matter, almost always evidenced by the darker color of the soil to a greater or less depth, is ordinarily accompanied by a corresponding abundance of humus, one is apt to consider this darker color as indicating a rich soil. This is not always true, though generally so as to soils of the uplands, second bottoms, and even well-drained riparian alluvials. On many farms in all parts of the state are areas of peaty or bog soils, and not unfrequently many areas of fairly dry uplands, the upper layers of which are almost black because of this large content of organic matter, but for all that unproductive. In the one case the blackish soil is too wet, so that the air is shut out, the result being a continuing loss of nitrates, where such exist, as well as the conversion of the organic compounds into free nitrogen gas, wasted into the air; or in the other, that, because of too little supply of soil moisture, the organic matters are in effect slowly burned with loss of all but the ash elements.

Upon all classes of lands, from the mountains to the Mississippi, there are such areas, upon which it seems that great stores of organic matters are in one way or another going to waste. Every working farmer observes the color as well as the consistency of the upper soil in judging the probable fertility of the field he is about to cultivate; and whether he thinks it or not, his judgment is dependent upon a comparison of the observed characteristics of land of known fertility—(new lands not exhausted), with those of the land with which he is about to deal. That he is sometimes deceived in his judgment we all know. Organic matter—vegetable and animal matter, of whatever kind, —the "volatile matter" of the analyses, is defined on page 39. This organic matter is the humus material of which we have spoken again and again. Without this material we can obtain no humus, and without an adequate supply of humus there is "no life in the soil." But this humus material is not humus, no more than corn is whisky. The debris of crops, stubble of grains or other plants, weeds, grasses or legumes, farm yard or stable manures, animal remains, etc., etc., are all humus materials; but they must undergo changes, physical and chemical, as well as the intervention of certain vital forces which we can name but of which we have as yet but a dim knowledge, that these materials, in themselves inert, may become the sources of renewed life and vigor. The prime results of what we call decay of organic matter are the imperfectly understood compounds for which we have the name humus,—compounds of carbon, hydrogen, nitrogen, and oxygen, in varying proportions of these four gaseous elements, with proportions of mineral elements differing in kind and amount because of the differing kinds of material from which they are derived.

Obviously the characteristic, the agricultural value, of humus, depends upon the kinds of materials from which it is derived. No farmer should be persuaded to waste any organic matter—humus material—of whatever kind. Such as furnish carbonaceous matter mainly have their places as agents in the changes which must be effected in the soil that it may be fruitful; such as belong to the nitrogenous group are peculiarly valuable, and should be sought for and husbanded most carefully.

The least fertile of the virgin soils of which analyses have been given in this Bulletin have a large supply of plant food elements, either in available form or in such condition that good management may render them available. The totals of mineral (ash ingredients) of plant food are stated. Nitrogen, as such, is not stated in the analyses. As to the probable amount of total nitrogen in the soil proper we are obliged to content ourselves with somewhat indefinite averages. Krocker, cited by Storer, observed that cultivated soils rarely contain less than one-tenth of one per cent of nitrogen in the surface foot. King states the average of thirty analyses of arable and grass soils in Great Britain, Illinois prairie soils, and rich soils of Russia, as high as .219 per cent. If we assume, as appears justified by the results of the work of competent investigators, that the surface foot of a virgin soil of moderate fertility contains about one-half of the total nitrogen contained to a depth of four feet, we are still more impressed with the importance of this essential element, which is in almost all cases relatively less abundant in the soils than any other element of plant food, and which as we have already seen is the most easily lost under bad management. Certain investigations conducted upon the Station farm, for details of which the reader is referred to the statement in the latter part of this Bulletin, may authorize the following estimates:

The soil No 15 (Dyer county) containing 4.373 % volatile matter, 1.626% humus, probably contained .095% nitrogen. In the surface foot per acre (this particular soil weighing 94.6 lbs. per cubic foot), there are probably 3,931 pounds of nitrogen. Under the most favorable conditions of temperature and moisture, and these favorable conditions subsisting for ten months of the year, it is possible that as much as four per cent of the total nitrogen may be converted into nitric acid and nitrates. That is, in this Dyer county soil, as we found it, there was promise of somewhere about 157 pounds of available nitrogen per acre in the surface foot of soil, and possibly half as much more in the next three feet of earth below, available for plants under best methods of cultivation. If there be to the full depth of the surface four feet, 157 plus 78, 235 pounds, of nitrogen in available form, there is apparently a superabundant supply, enough for three crops of cotton of one bale per acre. But, as stated on page 113, the losses of nitrogen by drainage are from one-half to four-fifths of the same element utilized by the plants. If the processes by which inert nitrogen compounds are made available as plant food could in any way be made to cease their activity, then absolute sterility might come to these fertile soils in less than three years. That such a dire calamity does not come so quickly is because of the fact above stated, that of the total soil nitrogen but four per cent under best conditions (and under prevailing methods probably less than two per cent), is annually converted into available form. If our cotton growing readers will recall the history of any one of their fields, they will find proof of all these things, and can better understand why lands that once produced a bale per acre are yielding at the rate of a bale to three acres.

Humus, from which is formed the humates (see page 36), is of very complex composition, because of the many different organic compounds from which it is derived. It is therefore of great importance that the character of humus material shall be understood as clearly as possible. To Harry Snyder (Journal of the American Society, September, 1897), we are indebted for exceedingly valuable data on this subject.

From humus prepared by mixing a variety of materials with soil, the mixtures placed in tight boxes and allowed to undergo humus formation for one year out of doors, Mr. Snyder obtained precipitates containing from 5 to 12 per cent of ash, with the following ultimate composition on an ash free basis:

HUMUS PRODUCED BY

	Cow Manure per cent.	Green Clover per cent.	Meat Scraps per cent.	Wheat Flour per cent.	Oat Straw per cent.	Saw Dust per cent.	Sugar per cent.
Carbon	41.95	54.22	45.77	51.02	54.30	49.28	57.84
Hydrogen	6.26	3.40	4.30	3.82	2.48	3.33	3.04
Nitrogen	6.16	8.24	10.96	5.02	2.50	0.32	0.08
Oxygen	45.65	34.14	35.97	40.04	40.72	47.07	39.04

"The differences here shown are noticeable. There is not a general similarity in composition between the humus produced by any two of the materials." "The nitrogen content ranges from about one-tenth of one per cent in sugar humus" (the nitrogen in this derived wholly from the nitrogen present in the soil of the mixture), "to nearly eleven per cent in the meat scraps humus."

Mr. Snyder determined the average composition of the ash from eight samples of precipitated humus as follows:

Insoluble matter (HCl)	61.97
Potash K_2O	7.50
Soda, Na_2O.	8.13
Lime, $Ca\,O$	0.09
Magnesia, MgO	0.36
Alumina, Al_2O_3	3.48
Ferric Oxide, Fe_2O_3	3.12
Phosphoric acid, P_2O_5	12.37
Sulphuric acid, SO_3	0.98
Carbon dioxide, CO_2	1.64

In order to obtain data upon the question, does the humus combine with the mineral matter of the soil to form compounds known as humates, by careful manipulation and analysis these results were obtained:

	Humic Phos. Acid, grams	Humic Potash, grams
Cow manure humus		
Original soil and manure	1.17	1.06
Final humus product	1.62	1.27
Green clover humus		
Original soil and clover	3.21	5.26
Final humus product	3.74	4.93
Meat scraps humus		
Original soil and meat scraps	1.07	0.25
Final humus product	1.18	0.36
Saw dust humus		
Original soil and saw dust	0.85	0.67
Final humus product	0.78	0.70
Oat straw humus		
Original soil and straw	1.02	2.42
Final humus product	1 03	2.41

"Some of the nitrogenous compounds seem to have a greater power of combining than the non-nitrogenous compounds. There is also a great difference in soils: some combine with the humus materials more readily than others." Concluding that it would be impossible to assign, from the analyses cited in his paper, any formulas for humus, Mr. Snyder nevertheless considers that its agricultural value is proportionate to its nitrogen content.

Although their decay upon or in the soil furnishes little nitrogen, no farmer can afford to burn the straw of his wheat or oats, the stubble of corn or other crops, if possible to avoid such waste. The carbonaceous matters have their value, and under certain conditions a very great value. There should be great hesitation before resorting to the too common method of clearing the fields by burning things "out of the way." On the other hand, every man should take thought for means of adding to the material for humus making, and endeavor to increase the store of such kinds of material as will most certainly and quickly be converted into active helping in soil feeding and soil fattening. This part of the work cannot be neglected, no matter how fertile nor how durable the lands. It is necessary upon the strongest limestone-clay lands, and is of the highest importance in the management of the silicious loams of West Tennessee.

CHAS. F. VANDERFORD,

Secretary Agl. Exp. Sta., Knoxville, Tenn.:

I send you herewith a statement of the mechanical analyses of the subsoils from Tennessee, sent to this Division by the Experiment Station. I understand that the samples as sent to me were the "fine earth" remaining after all the chert and gravel had been removed, and I am not informed as to how much of this chert and gravel were contained in the original samples.* This should be known for any intelligent discussion of the mechanical analyses, and in the absence of this information I can only discuss in a tentative way the peculiarities of the "fine earth" as shown from the mechanical analyses.

In the first place I should arrange these samples into two distinct groups, because I think you have essentially two different problems to deal with in the improvement of these lands. In the first group I have included all of the samples having less than 45 per cent of silt. In the second group I have included all of the samples having over 45 per cent of silt unless it is accompanied with a high percentage of clay, as in sample 718, which has 48.45 per cent of silt but has likewise 26.09 per cent of clay, which will offset in my judgment the large percentage of silt.

My experience has been that a soil having a large percentage of silt, say from 50 to 60 or 65 per cent., with a small percentage of clay, is very liable to deteriorate, becomes exhausted and worn out readily, and when so exhausted is one of the most difficult classes of soils to improve. A soil containing 60 per cent of silt and 15 per cent of clay may be very productive and yield good crops under judicious methods of cultivation, but it will not stand hard farming nor will it stand any neglect or ill treatment. A soil, on the other hand, like our Trenton limestone, with 15 per cent. of silt and 60 per cent. of clay, will stand almost any amount of hard farming, and neglect and injudicious methods of cultivation will not permanently injure the land. These lands always respond very readily to improved methods of cultivation.

Instances of these facts are not hard to find. The soils of the Eastern Shore of Maryland were from all accounts as productive as any in the State while they were kept up by the old planters before the war. With the changed conditions and the lack of capital and ready money to spend on farm improvements and on

*The samples sent to Mr. Whitney were those taken from the locations as described, the original bags forwarded precisely as marked and tied when filled. C. F. V.

thorough methods of cultivation, many of these once fertile lands are now turned out as barren wastes, and it will be difficult indeed to reclaim them. Some of the most refractory soils of the Eastern Shore are what are termed the "white oak lands." The subsoil of these lands is a tenacious white clay, almost impervious to water and being affected very seriously by extremes of wet and dry seasons. This material comports itself like a true clay and is heavy to work and nearly impervious to water, but a mechanical analysis shows that it contains very little clay, frequently not over 10 per cent., while it has a very large percentage of silt, ranging often from 60 to 70 per cent. These soils are much more difficult to improve than true clay soils in the same impervious condition would be. This may be due to the fact that the silt grains are relatively so large that when they become displaced it is very difficult to re-arrange them, as the forces within the soil are relatively small compared with the size of the grains. Clay particles, however, are so extremely small, their weight is so little compared with their surface area, that the forces within the soil tending to arrange or re-arrange the grains are relatively great in proportion to the dimensions of the grains of clay.

My experience has not shown that there are many of these soils in the Eastern States, soils depending upon a high percentage of silt for their water holding capacity rather than upon the amount of clay they contain, but they seem to be very prevalent in the Western States. I have examined about twenty-five samples from different parts of Illinois, supposed to represent the principal soil formations in that State, and most of these contain high percentages of silt. One portion of the State is covered with what is called "white clay" which proves very refractory and is frequently almost impervious to water. These were shown by the mechanical analysis to be composed mainly of silt and to contain very little clay. As a rule this so-called impervious "white clay" contains 60 or 65 per cent. of silt and not over 12 per cent of clay.

In Nebraska also some of the most impervious soils are these silty soils having from 60 to 70 per cent of silt and not over 8 or 10 per cent of clay. My experience has been that this class of soils require the greatest amount of care and intelligent cultivation to maintain their fertility, and they are the most difficult of all to improve when they have once been allowed to run down.

The general tendency in the deterioration of these soils is for them to become close and too retentive of moisture. Clay soils, on the other hand, are very liable to become too loamy and leachy and too little retentive of moisture.

You will see that the loess, the orange sand, the barrens and the flat-woods or Paris clays belong to this class of soils, having high percentages of silt and relatively small percentages of clay. The sandy cretaceous has a high percentage of silt, but it also has a large percentage of fine silt and clay which would probably offset the large percentage of silt. The Nashville limestone of Maury county has rather a large percentage of silt, but it likewise has a high percentage of fine silt and a moderate amount of clay, and the same may be said of the St. Louis limestone from Robertson county. It seems to me that this large percentage of silt gives the character to the first six samples of the second group and that the deterioration of these lands and the present unproductive condition of some of them all point to this same cause. Any intelligent improvement of these soils should be based upon this fact, that you have silt grains to re-arrange rather than grains of clay.

We find, as a rule, that soils having less than 40 or 45 per cent of silt and a moderate amount of clay will maintain conditions of moisture for the crops nearly in direct proportion to the amount of clay they contain. In some cases the clay is so arranged that it is more or less effective in its relation to the supply of moisture, but as a rule, under the conditions prevailing in the Atlantic States, the amount of clay determines the relation of these soils to moisture and the class of crops to which they are best adapted. Applying this rule to the examination of the soils in the first group of these Tennessee samples, I should say, without allowing for the amount of gravel and chert which has been removed from them and of which I know nothing, that the soils have an agricultural value about in the relative rank in which they are arranged in the table. The amount of chert will make a very material difference, but from the composition of this fine earth and considering this alone, I should conclude that they had the relative agricultural value shown by their position in the table.

The sample of Knox sandstone from Greene county is a typical soil for the bright tobacco, and the texture is almost identical with the bright tobacco soils of North Carolina and with the early truck lands of the Atlantic coast. This is too light in texture, and would probably be too little retentive of moisture with such a low content of clay and of silt, to adapt the soil to wheat or grass, and I should say that it was very poorly adapted to these crops, but very well adapted to bright cigarette tobacco and to truck crops. The two samples of Knox dolomite are shown to have very nearly the same mechanical composition, the amount of clay ranging about 24 per cent. Soils of this character in Maryland make moderately good wheat lands, but they are not considered the best we have by any means. The sample of the sandstone and conglomerate from Grundy county has rather more clay, and if it has not an excessive amount of chert I should judge that it would make a very productive soil. This is rather below the grade of our grass lands in Maryland, and I should not think the soil would be well adapted to that crop, but I should think it would be very well adapted to wheat and corn if this sample of fine earth truly represents the original material. The samples of the St. Louis limestone, the Knox shales, and the Lenoir limestone, contain much larger percentages of clay, and I should think these soils have such a texture as to form an excellent basis for fertile and substantial grass lands. I should say, from the mechanical analyses, and provided these samples of fine earth represent the original material, that these three soils were the strongest and best agricultural lands of any on the list.

If experience shows that these soils of the first group are materially out of place in the arrangement they have in the table, then a further examination should be made of the soils in place, for the departure of the agricultural value from its relative place in the group would indicate the trouble with the soil and would suggest the changes which should be made to make the soil productive. Their natural capacity should conform to the arrangement that I have indicated, and when they are all under the best possible condition, they would probably have this comparative value. As thus arranged, they are not all equally well adapted to the same class of crops, and the greatest success will come from the recognition of the conditions which they already maintain and of the peculiar adaptation of these conditions to certain crops. These soils should be applied to the specific class of crops to which they are each best adapted.

Very respectfully,

MILTON WHITNEY,

Chief of Division.

MECHANICAL ANALYSES OF TYPICAL SUBSOILS FROM TENNESSEE.

TENNESSEE	Orga'ic Matter	Gravel 2-1	Coarse Sand 1-.5	Medi'm Sand .5-.25	Fine Sand .25-.1	Very fine S'd .1-.05	Silt .05-.01	Fine Silt .01-.005	Clay .005-.0001
779 Greene County, Knox sandstone	1.81	3.54	5.04	14.60	15.77	17.36	17.47	16.82	8.13
712 Lyon's View, Knox County. Knox dolomite, lower measures.	3.13	0.25	1.17	9.53	9.66	8.07	31.98	9.06	23.87
710 6 miles north of Knoxville. Knox dolomite, upper measures.	2.61	1.42	1.64	6.98	3.97	7.14	38.12	13.12	23.89
720 Tracy City, Grundy County. Sandstone and conglomerate.	3.60	0.35	0.28	4.64	19.48	10.62	25.57	7.75	24.70
718 Maxwell Station, Franklin County. St. Louis limestone	3.57	0.00	0.14	1.31	2.59	5.01	48.45	10.61	26.09
716 Madisonville, Monroe County. Knox shales.	3.66	0.00	0.00	1.30	3.54	6.35	39.25	10.49	33.62
714 ½ mile north-east of Lenoir City. Loudon County. Lenoir limestone.	5.47	0.00	0.25	1.85	3.88	13.09	28.19	9.32	34.61
SOILS HAVING A RELATIVELY HIGH CONTENT OF SILT.									
739 Newbern, Dyer County, Loess (or bluff loam of Safford).	3.26	0.00	0.00	0.00	0.11	16.87	60.43	9.78	8.65
735 Humboldt, Gibson County, Lafayette (orange) sand (Sands here 12-16 feet below surface.)	2.93	0.00	0.00	2.73	2.50	5.03	60.92	14.58	10.58
722 1½ mile east of Tullahoma, Coffee County. Barrens. Silicious. sub-carboniferous.	2.78	0.00	0.00	0.86	1.31	9.04	65.65	8.46	10.66
731 1½ mile west of Camden, Benton County. Sandy cretaceous (Ripley group).	2.17	0.09	0.85	7.20	3.45	7.92	46.71	18.24	11.90
733 1½ mile north-east of Huntingdon, Carroll County. Flat-woods or Paris clays.	2.48	0.06	0.36	2.31	3.86	1.99	51.54	23.93	13.09
737 Somerville, Lafayette (orange) sands	0.36	0.04	0.19	0.91	1.04	5.19	60.28	15.38	13.15
724 Ewell Station, Maury County. Nashville limestone.	5.00	2.14	0.31	0.37	1.43	12.42	48.08	14.04	16.41
726 Adams Station, Robertson County. St. Louis (coral) limestone.	3.08	0.00	0.05	0.15	0.74	2.04	61.85	10.45	20.20

CHEMICAL ANALYSES OF TYPICAL SOILS AND SUB-SOILS OF TENNESSEE, GROUPED AS BY MR. WHITNEY IN THE ACCOMPANYING TABLE OF MECHANICAL ANALYSES.

SOILS CONTAINING LESS THAN 45 PER CENT OF SILT	Humus	Insoluble Residue	Residue soluble in Na_2CO_3	Potash, K_2O	Soda, Na_2O	Lime, CaO	Magnesia, MgO	Ferric oxide, Fe_2O_3	Alumina, Al_2O_3	Phosphoric Acid, P_2O_5	Sulphuric Acid, SO_3	Volatile Matter	Moisture
5·779 Greene County, Sandstone. Soil	0.730	89.896	2.659	0.092	0.054	0.050	0.085	0.832	2.185	0.021	trace	2.833	0.940
Sub-soil		91.995	2.655	0.058	0.033	0.046	trace	0.774	2.301	trace	trace	1.366	0.550
2·712 Knox County, Dolomite. Soil	1.490	80.197	5.478	0.180	0.114	0.060	0.213	2.133	5.205	0.074	0.014	3.900	2.350
1·710 Knox County, Dolomite. Soil	1.010	84.985	4.720	0.120	0.112	0.053	0.140	1.318	3.997	0.040	0.009	2.933	1.733
7·720 Grundy County, Sandstone. Soil	0.805	77.510	7.370	0.403	0.163	0.073	0.291	2.342	6.091	0.017	0.012	3.733	1.660
Sub-soil		76.585	8.180	0.373	0.142	0.067	0.306	2.455	6.631	0.01[illegible]	0.014	3.090	1.683
6·718 Franklin County, Coral Limest'e. S'l	1.536	75.520	6.958	0.340	0.132	0.100	0.265	2.928	6.475	0.022	0.010	4.900	1.960
Sub-soil		75.765	7.270	0.320	0.107	0.106	0.234	3.166	7.413	0.021	0.008	3.216	1.760
4·716 Monroe County, Knox Shales. Soil,	1.360	76.875	6.030	0.312	0.101	0.163	0.455	2.706	5.987	0.057	0.025	4.473	2.093
3·714 Loudon County, B'ue Limest'e. Soil,	2.150	73.128	6.197	0.380	0.171	0.180	0.342	3.012	7.695	0.104	0.018	5.983	2.350

CHEMICAL ANALYSES OF TYPICAL SOILS AND SUB-SOILS OF TENNESSEE, GROUPED AS BY MR. WHITNEY IN THE ACCOMPANYING TABLE OF MECHANICAL ANALYSES.

SOILS HAVING A RELATIVELY HIGH CONTENT OF SILT—OVER 45 PER CENT	Humus	Insoluble Residue	Residue soluble in Na_2CO_3	Potash, K_2O	Soda, Na_2O	Lime, CaO	Magnesia, MgO	Ferric Oxide, Fe_2O_3	Alumina, Al_2O_3	Phosphoric Acid, P_2O_5	Sulphuric Acid, SO_3	Volatile Matter	Moisture
15 739 Dyer County, Loess Soil	1.626	79.360	6 455	0.416	0 172	0.199	0.290	2.059	3 978	0 113	0 015	4.373	1.900
Sub-soil . . .		79 045	7.930	0 420	0.227	0.271	0.360	2 455	4 921	0.089	0 013	2.217	1.666
13-735 Gibson County, "Orange Sand". S'l	1 508	81.154	5.514	0.409	0.133	0 212	0.270	1.850	4 771	0.069	0.020	4.033	1.553
Sub-soil . . .		78.675	7 357	0.444	0 240	0.126	0 395	2 587	.5.604	0 054	0.021	2.383	1.733
8-722 Coffee County, "The Barrens". So'l,	1.068	86.895	3.660	0.218	0.074	0.100	0.090	1.775	2.540	0.010	trace	3.203	0 980
Sub-soil . . .		86.160	4.538	0.240	0.065	0.057	0.126	1.889	3.604	0.007	trace	2.226	0.853
11 731 Benton County, Sandy Cret'ous. S'l	0.739	88.776	3 482	0.285	0.101	0 093	0.157	1.265	2.640	0 020	trace	2.386	0 690
Sub-soil . . .		84.875	4.956	0.379	0.111	0.097	0.267	1 889	4.181	0.020	trace	1.850	1.026
12 733 Carroll County, Fl'tw'd Clays. Soil,	0.905	86,560	3.895	0.378	0.090	0 132	0.184	1.492	2.972	0.026	0 011	3.216	0.876
Sub-soil . .		83 438	5.846	0.435	0.100	0.100	0.216	2.078	4 455	0.017	0.010	2.066	1.106
14-737 Fayette Co., Typ'c'l C't'n L'nds. S'l	1.356	84.054	4.380	0.380	0.085	0.205	0 246	1.889	3.400	0 071	0.018	3.600	1.307
Sub-soil . . .		79 800	6.733	0.494	0.301	0.152	0.351	2.814	4 972	0.074	0.012	2.557	1.500
9-724 Maury Co., Nash. Blue Lim'st'n. S'l	2 919	76.045	6 390	0.410	0.172	0 510	0.290	2.096	4 281	0.158	0.031	6.966	2.476
Sub-soil . . .		79.612	5.920	0.435	0.182	0.398	0.328	2.284	4.228	0.142	0.025	4.216	1.666
10-726 Robertson Co., St Louis Lims'n. S'l	1.652	78.359	6.671	0.393	0 169	0.278	0.355	2.134	4 388	0.078	0 023	4.400	1.753
Sub soil . . .		78.868	7.526	0 431	0 230	0 139	0.290	2.304	5.574	0 047	0.024	2.766	1.400

Upon the Station farm a small field, 3.14 acres, was plowed and subsoiled to a uniform depth of fourteen inches. This field was divided into four plats, each 845 feet long by 40 feet wide. Plats 1 and 2 were to all appearance alike from end to end. Plats 3 and 4 lie along the east side of the slope of the ridge, and these two were, at the beginning of the experiment, like one to the other so far as could be judged from indications on the surface and to the depth stirred by the plow and subsoiler. The entire field had been several years in mixed grasses and was covered by a somewhat thin coat of the stubble of annual plants and scattered tufts of perennials. Plats 1 and 2 embraced the better land, the soil in better physical condition, requiring much less effort by the plow team than the stiffer lands of plats 3 and 4. The soil is derived from the same series of dolomite strata as the lands represented by type No. 2 described in this Bulletin. The history of this field is not definitely known, but at the outset of this particular series of experiments was considered to be a fairly well-kept bit of land. During the fall and winter of 1895 there was hauled from the cow-barn as fast as it was made, and scattered as evenly as possible, 16,000 pounds of manure upon plat No. 1; 4,000 pounds on plat No. 2. This manure was turned under to an average depth of four inches. Upon the surface of the plowed land were then applied broadcast: plat No. 1, 200 pounds acid phosphate, guaranteed 14 per cent. total phosphoric acid, with 100 pounds muriate of potash; plat No. 2, 400 pounds fine ground raw phosphate from the Southwestern Phosphate Co., of Nashville, Tenn., said to contain *28.5 per cent total phosphoric acid, with 100 pounds muriate of potash; plat 3, 100 pounds acid phosphate, with 200 pounds of muriate of potash; plat 4, 200 pounds acid phosphate, with 200 pounds muriate of potash. The entire field was planted April 23rd, 1896, and the various operations of cultivation were precisely the same on all the plats, begun and finished on the same day each time. The yield was: on plat 1, 82.35 bushels of shelled corn per acre; on plat 2, 61.21 bushels;

* Of this total, 3.2 per cent "available."

on plat 3, 42.39 bushels; and on plat 4, 34.75 bushels. When the crop was gathered, the stalks cut down, and the land plowed ready for seeding in the spring of 1897, the surface appearances of the whole field were so nearly alike as to prompt our visitors to say that such marked differences of yield were almost incredible. As a part of the work the Station is steadily pursuing, samples of soil of these same plats were taken on the 20th of March, 1897, before there was anything done upon the land, which had been plowed some weeks earlier. When these samples were taken the surface was bare except for a few scattered fragments of corn stalks, the soil compacted by rains but in good condition for working. The soil samples were taken to a uniform depth of eight inches, and from five different places in each plat, so as to get as nearly as possible accurate representations of the soil of the four plats.

The official methods of analysis of 1896–'97 were followed. For determinations of assimilable phosphoric acid and potash the method of Dyer was used. This work was done by C. A. Mooers, Assistant Chemist. Certain figures from the analysis No. 2 on page 45 of this Bulletin are given for comparison.

Insoluble Residue and sol.	Virgin Soil.	Plat 1.	Plat 2.	Plat 3.	Plat 4
silica	85.675	84.18	83.32	78.41	80.52
K_2O	0.180	0.27	0.32	0.47	0.38
Na_2O	0.114	0.17	0.20	0.25	0.23
CaO	0.060	0.11	0.10	0.11	0.11
$Al_2Fe_2O_3$	7.318	8.41	9.97	12.67	11.47
P_2O_5	0.074	0.054	0.070	0.062	0.057
Volatile matter	3.900	4.84	5.00	5.56	5.15
Humus	1.490	2.90	2.99	3.61	3.13
Nitrogen		0.129	0.114	0.113	0.092
P_2O_5 sol. in 1% citric acid (Dyer's method)		0.0137	0.0122	0.0065	0.0059
K^2O sol. in 1% citric acid (Dyer's method)		0.0204	0.0158	0.0160	0.0138

The entire field was planted to Soja beans and cow peas in 1897. These crops were very luxuriant, but, for controlling reasons, could not be weighed with accuracy. No further applications of fertilizers were made. The land will be planted in corn in 1898; no fertilizers are to be used. The resulting crop will be weighed. We can then estimate the residual value of the fertilizers as shown by the analyses above, modified by the growing of cow peas and Soja beans and three different methods of disposing of these crops. The plats are large enough to present results easily ascertained and of such marked character as to be readily understood and appreciated by any observant visitor to the Station farm.

From the analyses above and the statements preceding, it is shown that farm manure has a direct value because of its constituents; another item of value because of the readiness with which the resulting humus enters into the formation of humates. Farm manure has still another value, which was recognized throughout the season of growth, namely, the better condition of the soil as to moisture content throughout the dryer season of midsummer. Note also that, on plat 1 of the field we found, at the date of taking the soil samples, of the total phosphoric acid in the upper eight inches 25.3 per cent, and of the total potash 7.55 per cent was in assimilable form. In plat 2, 17.4 per cent of the phosphoric acid and 4.94 per cent of the potash were found assimilable. In plat 3, only 10.5 per cent of the phosphoric acid and 3.40 per cent of the potash; in plat 4, 10.3 per cent of the phosphoric acid and 3.63 per cent of the potash, were found assimilable. Dyer concludes that when as little as 0.01 per cent of phosphoric acid is dissolved from a soil by his method, it is justifiable to assume that it stands in immediate need of phosphatic manures. Upon plats 3 and 4 were found less than 0.01 per cent. No phospate manures have been applied since, nor will any be used for the crop of 1898. We shall examine the soils of these four plats in the same manner as in 1896, plant corn thereon, and again be prepared to compare the determinations of the chemist with the weighed results of the crop.

The account of this particular experiment is given here because, to those of us at least who know all the conditions, the figures obtained by chemical analysis in a very remarkable way confirm and give reasons for the results evidenced by the crops while growing and when weighed after harvest. The analyses show the "capital on hand" when the field was planted to beans and peas in 1897. We shall endeavor to determine by chemical analysis whether or not the supply of available plant food for the proposed crop of 1898 has been increased or diminished by the growing of cow peas, etc., and, later on, try to ascertain as definitely as may be, by the test of crop results, the better methods for disposing of cow peas and other leguminous plants as enrichers of the soil.

We have tried, in a simple and direct way, to state facts, and have ventured such suggestions only as are plainly justified by the chemical and physical analyses of the principal type soils of the State and the experiences of our best farmers.

We regard it as beyond dispute that on four-fifths of our farm lands the use of commercial fertilizers, or fertilizer materials, must come more and more into practice. The making, saving, and use of farm manures, the growing of crops specially planted for the purpose of adding to the humus supply, the careful husbanding of all materials which may be incorporated into the soil to aid in chemical, physical, and biological changes which must be actively persistent if fertility is to be maintained, are acknowledged necessary things. Just how each man is to do best, can be determined by experiment upon his own land, under his own conditions—not in hap-hazard fashion, with guesses at results, but according to definite plans, carefully set on foot, carefully conducted throughout, and carefully recorded "from start to finish."

A record of any farm experiment should contain the following data:

1. The nature of the soil and sub-soil; this based upon examination of the land in as many places as possible, to the depth of twenty-four inches at least.

2. Crop previously cultivated; how the land was prepared for such previous crop; quantity and kind of manure used, if any; and the character of resulting yield.

3. Manner of preparation of soil for the experiment crop.

4. The kind and quantity of fertilizer applied; when, and how.

5. Date of planting, and how it was done.

6. Date the stand was secured; condition and appearance of plants at various stages of growth.

7. Methods of cultivation; date of each working.

8. Memoranda of weather conditions from seed time to harvest, with special notes of excessive rainfall or of drought, and their effect on the plants.

9. Memoranda of injuries by insects, blight, rust, etc., with dates.

10. Final results, stating actual weights and measures.